ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XXXV., No. 18.

TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 281
Brick Street Paving in Jackson, Mich (illustrated). 282
Mr. Menocal's Reply to the Nicaragua Canal Commission..... 283
The Tennessee Centennial Exposition..... 286
A German Coal-Car Dumping Machine (illustrated). 286
Eight-Wheel Passenger Locomotive; New York, Ontario & Western Ry. (illustrated)..... 287
Effect of Magnesia on the Strength of Cements When Subjected to Freezing (illustrated)..... 292
The Steam Plant of the National Electrical Exposition (illustrated)..... 293
Four-Track Swing Bridge over Harlem River, New York Central & Hudson River R. R. (with inset, illustrated) 293
Formulas for Long Columns..... 294
Capacity Test of a Water Tube Boiler..... 296
Discharge of the 36-in. Riveted Steel Conduit at Rochester, N. Y..... 296
EDITORIAL NOTES 288
Mr. Menocal's Reply to the Nicaragua Canal Commission—The Proper Course for Friends of the Canal Enterprise—The New Jersey City Water Supply Specifications—The Attempt to Make a Close Corporation of the Canadian Society of Civil Engineers—The Influence of Magnesia upon the Durability of Cement Mortars Exposed to Frost.
EDITORIAL.
Bacteriological and Chemical Studies of Public Water Supplies..... 289
LETTERS TO THE EDITOR.....290, 291
The Deflection of a Steel Beam When Heated—Weighing Moving Trains (illustrated)—La Rue's Formula for Curvature of Chords on Bridge Trusses—The Evolution of Dredging Machinery (illustrated).

THE EXTENSION OF THE MANHATTAN ELEVATED Ry. system into the annexed district of New York is formally proposed to the city by Mr. Geo. J. Gould and Mr. Russell Sage. Plans submitted to the Mayor in connection with this proposition show the proposed routes above the Harlem River, and also a double-decked system from the Battery to the Harlem River. The Gould-Sage syndicate express willingness to expend $25,000,000 on such extensions, and would expect to operate them by electricity. They think that ordinary trains could be thus run from the Battery to Yonkers in 40 minutes, and express trains in 30 minutes. The express time is now one hour between these points. Full detail plans are being prepared for submission to the city.

CAR LIGHTING ON THE ELEVATED RAILWAYS of New York city is to be effected by gas or electricity instead of the present dim and ancient oil lamps. A bill has been passed by the New York legislature and signed by the Governor, providing that elevated railways in cities of over 1,200,000 inhabitants shall equip two-fifths of their cars with electric or gas lighting within two years, and the remainder within the following three years.

FREIGHT TRAFFIC ON THE ELECTRIC RAILWAYS of Brooklyn, N. Y., is to be instituted by the Brooklyn Heights R. R. A contract has been made with the National Express Co. for the transportation of baggage throughout the city on a plan similar to that employed on steam railways, and in a short time regular express cars will be running over all the lines controlled by the company. A number of the car houses will be converted into branch express offices. Wagons will be sent to any address, and goods will be taken to a branch express office, and thence transported by the electric cars to other branch offices, from which other wagons will deliver them.

THE SIMPLE AND COMPOUND MOGUL LOCOMOtives of the Pennsylvania R. R., now under trial are said to have hauled trainloads of 25 loaded refrigerator cars over the mountain division from Altoona to Harrisburg, Pa., 132 miles, in 3 h. 27 min. for the former and 3 h. 37 min. for the latter.

OIL FUEL FOR LOCOMOTIVES is to be used by the Southern Pacific Ry. on its engines south of Fresno. Should the results prove satisfactory and the oil supply of Southern California promise a sufficient permanent supply, the use of this fuel may be extended.

THE NEW EAST RIVER BRIDGE COMMISSION has received a report from Chief Engineer L. L. Buck, stating that gneiss rock was struck at a depth of 40 ft. below high water, and seams were encountered at 45 ft. and at 49 ft. At the date of the report the drill was down to 49 ft. 10 ins. and he hoped was in solid rock. The plans for the caissons and foundations are well advanced, as based upon the greatest depth given above, a span of 1,605 ft. and a vesed sine of 180 ft. in the cables, making the highest point of the cables 332 ft. above high water. Since writing the above the drill has reached a depth of 70 ft. 4 ins., with at least 14 ft. in solid rock.

BIDS FOR GARBAGE DISPOSAL IN NEW YORK CITY were received on April 27 by Col. Geo. E. Waring, Jr., M. Inst. C. E., Commissioner of Street Cleaning, as follows: Edw. Duffy, $60,000 a year; New York Sanitary Utilization Co., $89,990; Merz Universal Extractor & Construction Co., $144,000. The two latter companies bid about a month ago, the former then asking $169,900 and the latter the same as now. Bids for the disposal of garbage, ashes, street sweepings and other rubbish were received from the Garbage & Refuse Co., at $240,625, and Mr. Z. F. Magill of Troy, N. Y., at $305,000. Mr. Magill's bid a month ago was $348,000. No bids were received for the disposal of ashes, street sweepings and other refuse alone. It is expected that action on the bids will be taken next week.

THE CUTTING-IN SPECIAL FOR WATER AND GAS mains, described and illustrated in our issue of April 6, 1893, has been improved, and its range of usefulness extended since that date by its inventor, Mr. H. F. Dunham, M. Am. Soc. C. E., 150 Broadway, New York city. The ordinary method of inserting a special branch for a new main in an old line of pipe is to connect up the branch by means of an ordinary joint at one end and a sleeve at the other, thus requiring three joints. By the new method only two joints are required, the branch being constructed with an ordinary joint at one end and a special joint at the other, or branch end, which with the opening from the main part of the special into the branch enables the whole special to be turned to one side far enough to slip the special over one end of the cut main. The special is then brought into line and slipped forward into place. The special was first designed for an ordinary T-branch, but has since been adopted to a cross, and also a branch a few inches longer than those in common use, so an old hydrant connection can be cut out and a larger branch inserted. The special may also be used where a large service takes the place of several lead connections, the casting for this work being threaded for the different sizes of wrought-iron pipe. The cutting-in special is also made as a short length of pipe to replace a broken section and new gates can be inserted in old mains by the same method. The device in its various forms is made by R. D. Wood & Co., of Philadelphia.

MUNICIPAL OWNERSHIP OF WATER, GAS AND electric light plants is proposed for investigation by the National Association of Officials of Bureaus of Labor Statistics. At the annual meeting of the association at Albany, N. Y., June 23, 24 and 25, the best means of conducting such an investigation will be discussed by Prof. Wm. F. Wilcox, of Cornell University, Ithaca, N. Y.; Prof. Edw. W. Bemis, late of the University of Chicago, Chicago, Ill.; Mr. Osborne Howes, Boston, Mass.; and Mr. M. N. Baker, of the editorial staff of Engineering News. The investigation, if made, is not to be "for or against municipal ownership, but for the purpose of ascertaining all facts bearing upon this question." Further information regarding the convention can be obtained from Mr. L. G. Powers, Secretary and Treasurer of the Association, State Capitol, St. Paul, Minn.

A WATER POWER PUMPING PLANT has been put in at Austin, Tex., to lift spring water developed while putting in the foundations of the power house connected with the new dam. This spring caused the contractors much trouble, but it was finally controlled and led through the foundation wall. Measurements indicated a daily flow of 3,000,000 gallons, and the river supply being muddy at times it was decided to utilize the water of the spring. On Nov. 25, 1895, a contract was made with the Goulds Manufacturing Co., of Seneca Falls, N. Y., for two double-acting vertical, triple, power pumps with 10-in. cylinders and 12-in. stroke, designed to run 45 revs. per min. and to work against a pressure of 150 lbs., delivering 1,500,000 gallons each in 24 hours. The power to drive the pumps is furnished by a 24-in. horizontal McCormick turbine wheel, made by S. Morgan Smith, of York, Pa. The wheel will develop 250 HP. at 200 revs. per min. The whole plant occupies 11 × 30 ft. on the turbine floor. Direct pressure is used. The spring now supplies the whole city, it is said, but two more springs, near by, will be made available.

A WATER-POWER ELECTRIC PLANT is being installed by the Blue Lake Water Co., of Stockton, Cal., to furnish power for lighting and for power for industrial purposes and for a street railway. The water will be carried in a pipe line 3,000 ft. long, with a fall of 1,043 ft., and it is estimated that 20,000 HP. can be obtained, though at present the plant will be of only 6,000 HP.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of a train on the Honesdale gravity branch of the Delaware & Hudson R. R., April 23. The head brakeman was killed and several passengers were injured.——A glancing collision between a Pennsylvania R. R. express train and some freight cars of the Cincinnati, Hamilton & Dayton R. R., occurred at Dayton, O., April 26. A switch engine backed a cut of cars down a crossover track, striking one of the Pullman cars of the express. One passenger was killed and another injured.——Two empty sleeping cars attached to a westbound train of the Pennsylvania R. R. on April 23 broke away from the train on the heavy mountain grade west of Altoona, Pa., and ran back down the grade, colliding with another freight train. The engineman and fireman were badly hurt, and the wreck of the two cars was burned.

A CAVE-IN OF THE TUNNEL at Fairpoint, O., on the Cleveland, Lorain & Wheeling R. R., occurred April 20. It was caused by a derailed engine striking the side wall.

THE STEAMER "WYANOKE," of the Old Dominion Line, was sunk at Norfolk, Va., April 28, by fouling the bow of the cruiser "Columbia," which vessel was at anchor. No lives were lost. The "Wyanoke" was a side-wheel steamer, 238 ft. long, running between New York and Richmond. She was built at Wilmington in 1870.

A FIRE IN THE CABLE BUILDING, corner of Broadway and Houston St., New York city, occurred last week which tested the efficiency of the fireproofing of that building. The furnishings of three rooms on the third floor were almost entirely consumed, the heat being sufficient to melt the tips from the gas and electric fixtures and to warp exposed pipes; the damage, except that of smoke and water, was confined mainly to these three rooms, and no fires communicated to the floors above or below. The tiled partitions between the burned rooms remained intact and the plastering was still on the walls after the fire, except in the central room, and here only a small part had fallen from the ceiling, although the walls were entirely bare. The detail drawings of the fireproofing were inaccessible. Mr. Porter, architect for the Metropolitan Street Ry. Co. believed that the fireproofing had not only saved the building from destruction but had preserved from injury the iron structure in immediate contact with the fire.

A CYCLONE occurred in Clay County, Kansas, April 25, causing considerable damage to property and live stock. Eleven persons were killed and about 20 injured.

THE INCLINED ELEVATOR OR TRAVELING WALK, invented by Mr. J. W. Reno, is to be tried at the new entrance to the New York station of the Brooklyn Bridge. It will be about 3 ft. wide, and will have a moving floor operated by an electric motor. This elevator was described and illustrated in our issue of Aug. 25, 1892.

AN ELEVATED BICYCLE ROAD IN NEW YORK is being again discussed by the Metropolitan Association of Cycling Clubs. The plan provides for an elevated iron structure between the tracks of the Eighth Ave. surface railway; beginning at Chambers St., down-town, running along Hudson St. to Eighth Ave. and up this avenue to Central Park. The structure would be 30 ft. wide, sufficiently elevated to permit the passage of teams beneath it, and be divided in to three 10 ft. paths paved with asphalt and properly drained. It is proposed to charge a small toll, and if the scheme should prove successful the road would be extended the full length of the city. The Association contends that such a road is now a necessity. Another similar scheme, promoted by Mr. Lawson N. Fuller, proposes a third floor for bicycles as part of the scheme now being discussed for building a double-decked elevated railway from the Battery to Yonkers. He would charge a 3 ct. fare for the use of this road for bicycles, between the termini mentioned.

PILES FROM 100 TO 105 FT. LONG are being used by the Tacoma Land Co., of Tacoma, Wash., in replacing a portion of its sea wall with a pile and stringer wharf. The water is 30 ft. deep and the outer row of piles range from 100 to 105 ft. in length, 10 ins. diameter at the tip and 22 ins. at the butt. The piles are made from the "Washington Fir" (the Douglass Pine), and from the same timber a few piles were cut and recently used, 120 ft. long and 24 ins. at the butt. Sticks 90 ft. long, 3-car lengths, in squared timber are often shipped East; and it is expected that changes in the alinement of the railway will soon permit the shipping of 100-ft. lengths.

A CHIEF ENGINEER OF THE DEPARTMENT OF City Works of Brooklyn is held to be necessary under the charter of that city. Ex-Commissioner White thought that with engineers at the head of the several bureaus under his charge a chief engineer was not required. The incumbent under Mr. White, Mr. Van Brunt Bergen, having resigned, the new commissioner, Mr. Theo. B. Willis, did not appoint a successor. The Corporation Counsel now holds that there is no choice in the matter, and it is expected that a chief engineer will be appointed soon.

BRICK STREET PAVING IN JACKSON, MICH.

The accompanying illustrations show, in a most interesting manner, the methods of laying brick street pavement in Jackson, Mich. This particular piece of work included 3,500 sq. yds. of pavement, for which about 200,000 bricks were necessary. This street is 68 ft. wide between curbs and 99 ft. wide between property lines, and was formerly covered with from 8 to 10 ins. of macadam, well compacted by long use. This macadam was first turned up by a special paving plow, a steel center-draft plow without a mold-board.

FIG. 1.—LAYING CONCRETE FOUNDATION FOR BRICK PAVEMENT; JACKSON, MICH.

FIG. 2.—SHAPING SAND BED READY FOR BRICK.

The steel share is drawn to a point, about 2 × 3 ins., and is made adjustable so as to permit change in the depth of cut. The steel point is a separate piece of metal with a double end, so made that when the point is worn out it can be reversed and the other end used. The average depth of cut is not over 6 ins. and the street was twice plowed over lengthwise with the aid of four horses and three men; a driver, plowman and one man who added his weight to the plow by riding on the beam.

The street was then excavated to sub-grade, and rammed and rolled to proper grade and given the proper crown parallel to the finished surface. For drainage a trench, 8 ins. wide by 2 ft. below grade, was dug on each side, just beyond the line of the road, and in these trenches were laid hard 4-in. drain tiles with the joints well covered by tar-paper. These drains led to the catch-basins. The curbing was made of the best Medina sandstone, 4 ins wide, 18 ins. deep and in sections not less than 48 ins. long. This curb was cut with a bevel on top and made to fit the street pavement and the sidewalks; the stones were set in a full bed of gravel, or sand, backed up with 8 ins. in thickness of the same material, and laid with ⅛-in. joints for a depth of 14 ins.

Upon the sub-grade as crowned and compacted was laid 6 ins. of concrete made of 1 part best American hydraulic cement and 2 parts of clean, screened sand, well mixed dry and made into a mortar with the least amount of water possible; into this mortar was incorporated crushed granite, all passing through a 2 in. ring, and in sufficient quantity to leave a surplus of mortar where rammed. This concrete was laid and rammed until the free mortar appeared on the surface (see Fig. 1).

When set, this concrete base was covered with a cushion-coat of clean, sharp, screened sand, 1 in. thick when consolidated. The sand was first rolled by a hand roller and then finished off to a true surface with a surfacing-gage, or "strike," as shown in Fig. 2. In using this "strike," boards, 6 × 1 in., were first laid flat directly on the concrete, one at the curb-line and another at the center of the street. These boards served as guides for the ends of the "strike," which was shaped to correspond to the crown in the pavement and was drawn by four men over the sand. When the guides were removed the space left was filled with sand and swept to the proper surface.

On this finished sand surface the bricks were laid on their longest edge, at right angles to the street and with all joints broken. These bricks were shale fire-bricks, 2¾ × 4¼ × 8 in., thoroughly vitrified and glazed and costing about $12 per 1,000. It is a special brick, with rounded corners which give an excellent foothold for horses, and has been made for several years past by the Bennett Sewer Pipe Co., of Jackson, Mich. Fig. 3 shows the method of laying, which may be described as follows: About six men are generally employed, following the course across the street, and when well supplied with helpers each man can lay an average of 7,000 bricks per day under favorable circumstances. On Mechanic St., which is 42 ft. wide, six layers made a record of 70,000 brick in nine hours. The "tongman," shown on the right of Fig. 3, carefully picks out and replaces any broken or defective bricks; though few have to be thus removed. When the bricks are laid the pavement is well rolled by a 5-ton roller, and it is carefully swept by rattan or steel brooms both before and after rolling. A special brick, with edges bevelled to an angle of 45°, is used at the intersections of streets, with most excellent results.

After the final rolling and sweeping the joints between the bricks are thoroughly filled with a preparation of asphalt, containing 10% of pure Trinidad asphalt and such proportions of the residium of 600° F. distillation of coal-tar and of still-wax as will make a tenacious and water-tight filling. The preparation is used at a temperature of 330°, and is poured into the joints by means of a cone-shaped can which has a stopper in the point controlled by a rod leading to the hand of the workman. About a dozen boys are employed in this service, as shown in Fig. 4. The pavement was finally covered with a top-dressing of ½-in. of fine sand, which was left on for a few weeks but removed before the final acceptance of the work. The surface of the finished pavement at the gutter is 6½ ins. below the top of the curb; and the spring, or crown, is 6½ ins.

In another street in the same city the pavement was laid without concrete, a 6-in. foundation of sand was employed, tamped, hand-rolled and struck with a gage to a true surface. Upon this sand foundation a course of bricks was laid on the flat and at right angles to the street-line. These bricks were covered with sand and the cracks well filled with fine sand well swept into the joints and the surface was then gone over with a 5-ton roller. One inch of sand was then put on as a cushion-coat, rolled and surfaced as before described, and on this was laid a top layer of brick edgewise, asphalted and finished as in the other street.

FIG. 3.—LAYING BRICK AND REMOVING DEFECTIVE BRICK.

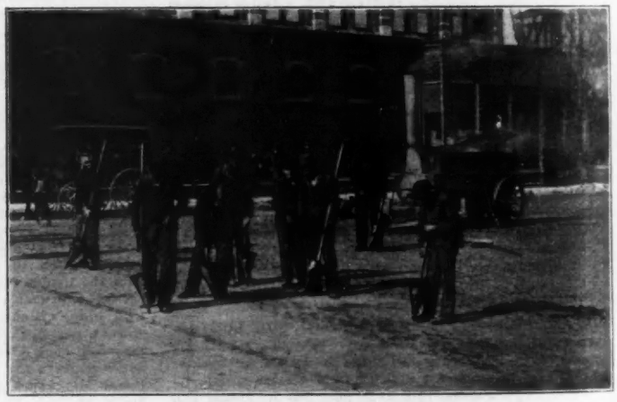


FIG. 4.—ASPHALTING JOINTS AFTER LAYING.

The prices of work on the concrete base were as follows, labor costing $1.50 per day in Jackson:

For grading, 25 cts. per cu. yd., with a maximum haul of 1,500 ft., and 1 ct. extra for each 100 ft. over 1,500 ft.; for drain-tile, 4 cts. per lin. ft.; for Medina curbing, 56 cts. per lin. ft.; for paving, $1.75 per sq. yd., which was the engineer's estimate. For the two layers of brick the cost per sq. yd. is about 10 cts. less than for the concrete base and a single layer of brick. These prices must be considered in connection with the fact that payment was made with city improvement bonds.

It is an open question whether sand-filling in the top joints, where fine sand is carefully used, would not be as good as the asphalt, which adds about 10 cts. to the cost per sq. yd. Sand will penetrate the cracks even better than the asphalt, and on Main St., a pavement laid with sand has been in use about five years and water stands on the surface until evaporated. As asphalt has only been recently used in Jackson no comparison can yet be made.

For this very full exhibit of the methods of street-paving employed in Jackson, we are indebted to Mr. Alfred E. Vandercook, of the Bennett Sewer Pipe Co., and to Mr. Thaddeus C. Brooks, of Jackson, the contractor. And we also acknowledge our obligations to Mr. T. Spencer Miller and to Mr. Frank B. Knight, of the Lidgerwood Manufacturing Co., who procured for us the photographs and description here used.

MR. MENOCAL'S REPLY TO THE NICARAGUA CANAL COMMISSION'S REPORT.

In our issue of March 26, 1896, we published the report of the Board of Engineers appointed by the President to report upon the feasibility of the Nicaragua Canal. This report has been under consideration by the House Committee on Commerce for some months, and hearings have been held upon it, as has been briefly noted in these columns. A reply to the criticisms made by the Board has been prepared by Civil Engineer A. G. Menocal and submitted to the committee, and we print it herewith nearly in full as follows:

The first and continually prominent fact that commands attention in considering the report of the Board of Engineers appointed by the United States Government to consider the feasibility, etc., of the enterprise, is that the subject is treated by the company and by the Board from two entirely different and distinct points of view. The company regards and has treated the project as a business enterprise, with a view to commercial requirements, technical success, and financial results. The Board entirely ignores two of these conditions and considers it from the point of unlimited expenditure without any question as to financial results, and provides beyond commercial requirements of the present for the accommodation of demands that, at the utmost, can only be claimed to be rarely occasional. The only point on which there is agreement is the entire feasibility of the project. As to this, the claims of the company are conceded by the Board, and any difference that exists as to the methods by which the work may be achieved is measurable by increased cost of construction. Whether such increase of cost is a necessary factor in the problem is then the question at issue, and that to which I have particularly directed my attention.

The canal projected and estimated for by the company is intended to be built and operated by a private corporation, with private capital and as a business enterprise. It is to be large enough to pass safely all the traffic likely to seek the route, but to be constructed economically, so as to pay reasonable returns on the capital invested. There is a marked distinction between such a waterway and an ideal canal, of ideal proportions, built regardless of cost. It is claimed that the canal designed by the company is ample to satisfy the requirements of commerce and larger in its dimensions than any other ship canal built and in actual operation in the world, except, if they can be classed as ship canals, the waterways joining the American lakes, in which the conditions of traffic are peculiar to those localities and entirely different from those pertaining to ocean traffic.

The Board lays considerable stress on what is claimed to be the insufficiency of the hydraulic and geological data collected by the company, and dwells at great length on the need of the fullest and most precise information, accurately recorded and carefully studied, of the varying rainfall and floods of the lake and rivers, the gaging of all the water courses concerned, following their variations of volume and velocity throughout their ranges, etc., before engineering works, such as have been proposed for the construction of the canal, can be decided upon; and adds that, even with such data most carefully ascertained, allowance would still have to be made for possibilities occurring at long intervals. This information, the Board says, has not been secured.

The importance of such data in designing and executing the works proposed is fully recognized and the deficiency referred to in the records of the company is admitted; but all practical engineers are aware of the fact that even in countries of limited and comparatively regular rainfall, the attainment of such information must be the result of many years of persistent, careful investigations, extending over a large area of territory, with numerous permanent points of observation. In a country like Central America, where the range of rainfall in the same locality varies as much as 100 ins., from one year to another, and 200 ins. or more in the same year between points less than 100 miles apart, theories based upon observations extending over twenty years may be entirely upset the twenty-first.

The concessions granted by the Nicaraguan Government provided, under penalty of forfeiture, that the final surveys for the location of the canal should be completed within 18 months from the date allowed for commencement, and that the final plans be filed and the work of construction commenced within 2½ years from the date of the grant. The fragmentary hydraulic data obtainable in that short length of time, while the project was in process of development, would have been of no more value in connection with the design of dams, weirs, and other works, than will be the information proposed to be obtained by the Board in the 18 months' additional surveys recommended. In the absence of this unattainable exact information the engineer familiar with the topography and varied meteorological conditions of the country must assume generally coordinate conditions on which his works are based, and then to be on the side of safety make liberal allowances for a possible maximum. The work of preparation and actual construction will extend through a number of years, during which valuable data will be secured to which the works must be adjusted in their completion. There is no other practical method possible under the circumstances, and with the proper exercise of judgment the work is reduced to a minimum. This method is also much simpler than to go through lengthy, complicated theoretical calculations, based on assumed watersheds, rainfalls and run-offs, all far from actual conditions, and leading to conclusions worse than valueless, because, to those unfamiliar with the country, they are misleading. In the case of the River San Juan, at Ochoa, it was assumed that the maximum flood might reach 63,000 cu. ft. per second, and provisions were made for a discharge of more than double that amount from the basin of the San Juan, with a maximum rise not exceeding 4 ft. The Board has returned from its trip to Nicaragua with the impression that the maximum flood may reach 150,000 cu. ft. per second. This estimate is, in my opinion, a rough and excessive guess; but assuming it to be nearer the correct figure than the company's estimate, the problem is reduced to one of detail; that is, to increasing the length of weir crest and sluiceways so as to provide for the estimated additional discharge. That the minimum flow of the River San Juan may be less than 11,390 cu. ft. per second, as shown by the gaging of May, 1872, is not disputed, as the lowest level of the river has not been established, but the extraordinary low water of that year is a matter of record recognized by boatmen and those living along the stream; but that the flow may be as little as one-half or one-third that amount is not admitted, and the rough gaging made by the Board near the lake in May, 1895, cannot be accepted as of sufficient value for comparison.

The maximum fluctuations of the lake level, as near as can be determined, from the information obtainable, is about 10 ft. The level 196.6, given by the Board, as reported by an engineer in Nicaragua, is inadmissible, as such low lake would practically cut off the flow of the San Juan below Toro Rapids, an event not recorded in the history of the country. The fluctuations of lake level and discharge will be controlled by the Ochoa dam. The flow of the river will be more uniform by reason of enlarged sectional area in the created storage reservoirs and lessened fluctuations of lake level; and with an intelligent management of the sluices and weirs, at both the western and eastern ends of the summit level, there is no reason why the lake should not be maintained within 1½ ft. of the assumed 110-ft. level, as proposed in the company's plans. With the regimen of the river and lake thus regulated, the flow will be more uniform and far more in excess of the amount required for necessary lockage than has been estimated.

The Board questions the estimate of ⅝ in. per mile slope allowed in the river from the lake to Ochoa, and, without assigning valid reasons or presenting any figures to disprove it, presents an estimated slope of 0.2 ft. for this entire distance, based on a discharge of 10,000 ft. per second. There is no data at hand on which to base computations conducive to even approximate results, as the constantly varying section of the river and conditions of the banks and the contractions and expansions of the flooded valley at every point will result in variable conditions of flow, which cannot now be ascertained. But it is of direct interest to observe, in this connection, that in the section of the river called "Aguas Muertas," between Machuca Rapids and the confluence of the river San Carlos, where for a distance of 18 miles the depth varies from 40 to 80 ft., the slope of the river, for a flow of 11,000 cu. ft. is nearly 1 in. per mile. The sectional area of the river above Machuca Rapids, as modified by the dam, and exclusive of expansions of the valley where the current will be nil, will not vary materially from the dimensions given for the "Aguas Muertas" section, and it may be fairly estimated that the slope will be about the same. Nearly similar conditions of slope obtain between the lake and Toro Rapids. The estimated slope of ⅝ in. to the mile assumed for the plan of the canal is, therefore, insisted upon as approximately correct until disproved by some substantial reason or by computations not yet submitted by the Board, and the unsupported assertion that the lake level of 110 ft. will be extended to Ochoa, and that the dam and embankments should be raised 4 ft. by reason thereof is, in my opinion, unwarranted and inadmissible, and the increased cost due to that change should be regarded as an unreasonable addition to the estimates.

The Board attaches considerable importance to retaining the lake level at or above 110, and believes that any fall from that level will be injurious to navigation in the river and canal. There is no foundation for the statement. The canal is projected to be, ultimately, 30 ft. deep throughout from ocean to ocean, but in order to reduce first cost of construction the river section and the sea-level sections of the canal have been estimated with a depth of 28 ft., the additional 2 ft. to be excavated after the canal is open to traffic. It is claimed that the lake level can be maintained within a range of 3 ft., or within 1½ ft. of 110, and the Board does not seem to dispute it. Should the lake fall 18 ins. below the 110-ft. level the excavated channel in the river will yet have a depth of 26½ ft., or 6 ins. more than the Manchester and Suez canals, and the sections of canal in excavation a depth of 28½ ft., or deeper than any ship canal in the world. That is to say, the lake may fall 2 ft. below the assumed summit level, 110, and all the sections of the river and canal in excavation will yet remain deeper than any other canal now in successful operation, and there is no apparent reason why this canal should be made deeper than experience has conclusively shown to be sufficient elsewhere.

Owing to lack of time and the pressing need of carefully surveying and developing vast sections of the country not previously examined and entering as important factors into the problem of designing and estimating the cost of the canal, the company was not able to make a new and more detailed survey of the river San Juan before operations were suspended. This omission has not, however, the importance attached to it by the Board. The river had been surveyed by a party of navy officers, specially trained in hydrographic work, under the immediate charge of Lieut. J. W. Miller, acting under the supervision of Commander E. P. Lull, U. S. N., commanding the government surveying expedition of 1872-1873. The company had the free use of the field notes and original plans of that survey, and there is no reason to doubt the accuracy of the survey or the sufficiency of the estimates based on the same. The compass survey referred to by the Board was set aside, not because it was valueless, as stated in the report, but for the reason that the company had it in contemplation to supplement the government survey by a thorough and complete survey of the stream and its adjacent valley as far as Ochoa, with numerous cross sections and borings from the lake to Castillo. There being no question, however, as to the entire practicability of that portion of the canal, the engineering force was kept employed in developing other less known sections of the country and in rectifying the location of the canal and locks and embankment sites until a suspension of work on account of financial difficulties found the river work yet undone.

I will now discuss the changes in the design of the canal recommended by the Board in order as they appear in the report:

1. Greytown Harbor.—The Board accepts as correct the principles on which the plans proposed for the restoration of the harbor are based, but recommends that the pier and harbor entrance be shifted about 1½ miles to the eastward, on the ground that as located on the plans of the company it is too near the angle formed by the west coast. The change is not regarded as advisable for the following important reasons:

1. The Government of Nicaragua will not assent to it. The canal concession provides that the company shall build one first-class harbor on the coast of Nicaragua at each terminus of the canal, on the Atlantic and Pacific oceans. The first locaton for the harbor entrance made by the company was several thousand feet to the eastward of the present location, but the government of Nicaragua insisted on the removal of the proposed breakwater and harbor entrance to the westward, on the ground that the site selected was on disputed territory between that Republic and Costa Rica; and the present location was the result of a compromise on that point between the company and the government.

2. The five and four fathom curves lie five-eighths of a mile and one mile respectively west of the pier head as proposed, and therefore ships entering or leaving the harbor will have considerable more leeway than is allowed at the entrance of the best artifical harbors in the

world. Ships arriving off Greytown generally anchor to the westward of the proposed pier extended, showing that the objection raised by the Board is not well founded.

3. The suggested change would increase exposure to the northwest, with consequent agitation at harbor entrance.

4. It would bring the pier and harbor entrance into dangerous proximity to the mouth of the lower branch of the river, with imminent risk of being undermined and destroyed at the root, or of being converted into an artificial island by scouring of the coast and shifting of the river into a new channel to the west of the pier.

5. It would greatly decrease the area of deposit for the drifting sand arrested by the pier, and consequently involve an unnecessary increase in length of pier.

6. It would involve an unnecessarily enormous increase of cost over present estimates.

7. The advance noted on the west coast line, as reported by the Board, is due to accumulations of the uncontrolled sands drifting westward, which will be completely arrested by the pier, and no apprehension need be felt as to construction and permanency of harbor entrance as proposed in the company's plans.

2. Greytown Harbor to Lock No. 1.—The change of canal location recommended between Greytown and Lock No. 1 is not advisable, for the reason that it would require expensive and dangerous diversions of the River San Juanillo, and interference with the natural drainage of the country, without thereby gaining any material advantage over the present location. Such a line was located by the company and discarded in favor of the one through Benards Lagoon, which is more economical in construction, and leaves the San Juanillo undisturbed. Had the Board visited that section of the canal location it would have obtained some idea of the topography, and have seen that Benards Lagoon is a lagoon only in name; that it is similar in character to the various swamps extending several miles back of Greytown, and that it offers no more difficulty in being cut into with the canal prism than those that have already been dredged through by the company.

The proposed change in the bottom width of the canal from 120 ft. to 100 ft. is not in the interest either of economy or of a better canal. The first proposition is proved by the estimate of the Board and the second by the experience gained in operating the Manchester Canal, which is, as the proposed Nicaragua Canal, 120 ft. wide at bottom. The assertion of the Board that such a width is not sufficient to allow the safe passage of ships traveling in opposite directions is disproved by a late report of the officials of the Manchester Canal to the effect that ships traveling at the rate of 6 miles an hour pass one another at all points without difficulty. The turnouts proposed by the Board have proved a source of annoyance and delay to navigation in the Suez Canal, by reason of frequent grounding of vessels in taking and leaving them, and they should be avoided. It should be observed that with a bottom width of 120 ft. and slopes of 3 to 1, as proposed in the plans, ships drawing 20 ft., which may be accepted as the average draft of vessels using the canal, will have a clearance of 180 ft. between banks, and with a draft of 25 ft., which may be taken as the maximum, the clearance will be 150 ft., which is much more than the navigable width at those depths in the Manchester Canal, where the slopes are much steeper.

3. Lock No. 1 to East Divide.—The Board finds no special mechanical or other engineering difficulties in the design and construction of locks of the lifts proposed in the company's plans, but thinks it would be preferable to have four locks of uniform lift instead of three as proposed. The change would materially increase the original cost and the operating expenses without gaining any advantage to navigation. Locks of 31, 35 and 40 ft. lift, as proposed, conform much better to the topography of the country, will be less expensive in original cost and maintenance, and offer less obstruction to navigation, and therefore the proposed change is not desirable. As to the recommendation that the locks be built 80 ft. wide in the chamber, there is no objection to the proposition beyond the increased cost. The width estimated for by the company (70 ft.) is, however, quite sufficient for the unimpeded passage of all vessels likely to pass through the canal, and no waterway built as a commercial undertaking can afford to be overloaded with extra cost for the purpose of making provisions for the passage of a few ships afloat of unusual dimensions which may never have occasion to use the canal.

East Divide.—No definite changes have been proposed in the section adopted for the "eastern divide cut," but it is pointed out that more borings will be needed to determine with precision the exact character and amount of rock to be removed. The cut is short of three miles long, and there were 38 borings taken in that distance. Of that number, 22 borings were made with the auger through the overlying clay to the rock, and 16 were made with the diamond drill in the rock, penetrating to the bottom level of the canal. While these borings showed some variations in the consistence of the rock, there is no indication, either in the cores brought up or in the large masses of rock in view at the Falls and in the bed of the Deseado, of stratification, clay seams, or disintegrated material, suggesting the probability, or even possibility, of the sliding of the mass from the sides of the excavation.

Railroad and Telegraph Lines.—The company has provided for a single-track railroad between Greytown and Ochoa, and has estimated it at a price per mile sufficiently high to include the necessary sidings, water tanks and stations, such as are required during construction, but exclusive of such switches and other temporary tracks as may be needed in the vicinity of the works, the cost of which being chargeable to are included in the estimate of the various works to which they pertain. The Board is of the opinion that a double-track road will be needed for the business west of the east end of the divide cut, and has increased the estimate accordingly. Considering that this road is to be built strictly for construction purposes, and for no other business, it is believed that even if the traffic westward should be as large as the Board assumes, a well built and intelligently managed single-track road will be quite sufficient for the business.

The Ochoa Dam and San Carlos Ridge.—The report devotes considerable space to the discussion of the proposed Ochoa Dam. It calls attention to the lack of hydraulic data and insufficient borings taken by the company at the site of the dam. The matter of hydraulic data has already been discussed in this paper and repetition here is unnecessary. As to the borings, it will be sufficient to say that enough of them were made to establish the fact that there is no solid rock ledge within practical distance available for foundations at the site of the dam. That the abutting hills are composed of compact, hard, red clay, with occasional bowlders, and the bottom of the river of sand to considerable depth. Whether the rock lies 100 ft. or 200 ft. below the river bottom is of little moment as long as it is too deep to admit of being used for the support of the structure.

To continue boring after these facts had been established would have been a waste of time and money, and operations were therefore suspended after seventeen borings had been made. It was evident from the borings that a masonry dam of the height required was not practicable at that point under existing conditions, and either a more suitable site had to be found or a method of construction adopted suitable to the conditions found. Careful investigations showed that there is no practicable site for a dam between Machuca and Ochoa, due principally to the great depth of water in the "Aguas Muertas" section of the river, and that there is but one available site below, about five miles from Ochoa, which presents no advantages over the upper site, the physical conditions being practicably identical. The site at Ochoa was, therefore, adhered to, and a rock-fill dam was adopted as the only safe and economical solution of the problem. The dams described by the Board cannot be accepted as parallel cases, and they throw little or no light on the problems in question. They were built of small stones, packed by hand, with steep front and back slopes, and on rock foundations. They were built for the storage of water, were not intended to be overtopped, and as might have been expected were, with one exception, carried away as soon as a large volume of water commenced to flow over their crests. It is quite remarkable that one of the dams described (the Bowman dam, successfully resisted the flow of a considerable volume of water over its top, a circumstance due, evidently as much as to any other condition, to the larger size of the stone used in its construction. In searching for precedents of rock-fill or dry-rubble dams built on sandy bottom to withstand the flow of large volumes of water over their tops, we will have to look at the irrigation works of India, where such methods of construction have been in practice for many years. Rough stone weirs exist at the heads of most of the irrigation channels in Misan, which raise the level of the water to the required height, the lowest being 7 ft. and the highest 25 ft.

The Mudden weir is 22 ft. high and 168 ft. at base. As originally constructed it consisted of a mass of rubble, paved with larger stones, the front face with stones 1½ by 1 ft., while the apron was paved with rough stone blocks of about 2 cu. yds. each. That this weir should have stood, with but occasional repairs, for a great number of years, is quite remarkable, on account of the small stones comprising its mass. It was recently reconstructed, and the original form was retained by the engineer, but a brick-and-mortar wall was introduced against the upper face to prevent the displacement of the small stones. The weir at the head of the Agra and Soane canals represents a quite usual type of rough weirs built in sandy bottom. This weir is without solid foundation of any kind, resting directly on the sandy bed of the river. Its crest is 10 ft. above the river bed and its length 2,575 ft. The flood discharge is as high as 1,300,000 cu. ft. per second, the depth of water over the crest in flood discharge being about 10 ft. The Soane weir is similar to the Agra weir in general construction; it rests on wells sunk from 6 to 8 ft. in the sandy bed of the river, three narrow masonry walls being used to keep the small stone in place. Between the walls is a simple stone packing. The upstream slope is 1 on 3, and the downstream slope is 1 on 12. The weir is 12,470 ft. long, and the height, including depth of wells, 19.3 ft. Flood discharge 750,000 cu. ft. per second. The weir at Begewada, in the Kistna Deltaic works, is 3,198 ft. long and 15½ ft. high above top of foundations, which consist of a double row of walls sunk in the sandy river bed. The flood discharge is 736,000 ft. per second, and at the greatest flood the water rose 19½ ft. above crest of weir. It will be apparent that such works could not be built in one dry season, and the floods must have passed over them during construction. Many similar weirs could be cited of about similar dimensions and built on the same conditions and by similar methods as those described above.

Not any of these weirs approach in height the one proposed at Ochoa, but the precedent of rock-fill dams or weirs, built on sandy river beds successfully withstanding the undermining effects of a considerable hydraulic head and the flow over their crests of enormous volumes of water is fully established; all that is needed in the case of Ochoa being to proportion the structure to the height required. The cross walls used in the construction of the weirs in India to prevent the rolling of small stones can safely be dispensed with in this case by using large blocks weighing from five to ten tons in the body of the whole mound, as has been proposed. That these stone blocks will gradually sink in the river-sand bed as the work progresses, by the scouring action of the increasing head is fully admitted; but if the practical results obtained in India, especially at the Agra weir, and in many brush and timber dams built in sandy rivers in the United States, can be taken as a criterion, the mound at Ochoa will not sink more than 15 ft. in the river bed under a head of 60 ft., the base of the rock mound being not less than 900 ft. in length. The Agra weir rests on the bed of the river without foundation of any kind, practically floating on sand, the friction under its long base being solely depended upon to overcome the hydraulic head.

The Board admits the practicability of the dam, with some modifications in the method of construction. The first consists in strengthening the abutments by means of concrete piers sunk with the aid of caissons, and the second and most important change proposed is to build a series of sluices in the surrounding ridge of the San Carlos basin, by which the whole volume of the river in flood can be diverted from its natural channel when the mound has attained a height of about 50 ft. above low water level, and the rest of the dam to be then built to completion practically free from water. The first proposition involves a mere matter of detail, and while I regard it as practically of no advantage, and therefore extravagantly and unnecessarily expensive, it need not be discussed at length.

The second proposition is, in my opinion, of the greater importance. It would be an element of weakness in method, and if carried out it is most likely to result in at least temporary failure. I claim that the assistance of the river is essentially necessary during construction by the method proposed, in order to obtain a permanent structure. The hydraulic head should be constantly acting on the base to attain and to keep up the maximum scour and the settlement of the whole mass, and the flow will be a powerful and valuable agent in distributing the material over the work in progress, until every block and every pebble has found a final resting place. But if a portion, and the most important part, of the dam is built free from water, it is more than probable that when the whole pressure is brought to bear upon the structure a sudden settlement of the mass will take place; the dam may be breached thereby, and the resulting injury to the work may be very serious, and to say the least, expensive to repair.

If the method of construction recommended by the company's plan is adhered to, there will be no danger in allowing a portion of the river flow to discharge over the dam. If all the parts composing the mound have in their turn successfully stood a proportional share of the full force of the stream acting on the whole mass, there is no good reason to fear that a much reduced flow will endanger stability. However, that is a matter of detail, and the fact that by raising the dam crest above the highest probable water level in the river the stability of the dam is placed beyond all possible contingencies of accident need not be disputed. But I firmly assert that the method I have outlined for building the dam is the safest, as well as the most economical, and that the modifications proposed by the Board are, first, unnecessarily costly, the auxiliary sluices alone being estimated at $1,500,000, and next dangerous as regards stability of the structure. With the sluices and weirs proposed by the company, the summit level can be regulated and the surplus waters safely discharged, and if later investigations should show that the probable maximum floods may be greater than have been estimated, additional weir crest can be provided in due time during construction.

The San Juan River.—The Board believes that the channels proposed by the company's plans in the river San Juan and at the east side of the lake, where excavations are needed to obtain the required depth for navigation, viz., 125 ft. wide at the bottom in the river section and 150 ft. wide in the lake, is altogether too small, and recommends bottom widths of not less than 250 ft. in the river and 300 ft. in the lake. Such widths of channels are, in my opinion, unnecessary, and at the outset undesirable on account of the enormous increase of cost

involved. There is no ship canal in the world of such a channel width, with the exception of the canals between the American Great Lakes, if they can be called ship canals, where the conditions of traffic differ entirely from those pertaining to canals built for the accommodation of ocean traffic.

During the season of 1895, of 231 days, 17,956 vessels passed through the St. Mary's Falls Canal, of which 12,495 were steamers, 4,790 sails, and 671 unregistered craft, or an average of 78 vessels per day, with an average tonnage of 935, carrying an aggregate of 15,062,580 registered tonnage, showing an increase of 7,399 vessels and 6,508,145 tons since 1890. With an estimated traffic of 10,000,000 tons, extended over the entire year, and an average tonnage of 2,500 tons, the number of vessels passing through the Nicaragua Canal per day will be 11, as compared to 78 going through the St. Mary's Falls Canal, and for a traffic of 6,000,000 tons the number of ships passing through Nicaragua will average less than 7 per day. The conditions of traffic are also entirely dissimilar. In the lake traffic the distances are comparatively short and the competition sharp, and every hour saved and each mile made represents an appreciable item in the profit and loss account for the trip, while ships passing through the Nicaragua Canal will save hundreds of thousands of miles and days instead of hours in the length of the voyages, and the loss of a few hours by detention would play no part in the expense of the voyage. The matter of speed is, therefore, of vast importance in lake navigation, but of far less consequence in an interoceanic ship canal. A wide channel, in which steam and sailing vessels and large tows can travel at full speed, and pass one another at all points without hindrance, is necessary in the former case, while at Nicaragua, with a limited number of ships traveling at comparatively low speed, a much more contracted channel will be sufficient to meet requirements, as has been proved by experience in other ship canals..

Lake Nicaragua.—What has been said of the river channel can be applied with greater force to the lake channel 150 ft. wide at bottom, with slopes of 3 to 1, as estimated in the company's plans, or slopes of 5 to 1, as is quite possible, may be needed on account of the soft nature of the bottom. With such slopes, vessels drawing 20 ft. will have a clearance of from 210 to 250 ft. between the banks, and for a draft of 25 ft. the clearance would be from 180 to 200 ft. I am of the opinion, therefore, that the width of channel proposed by the company's plans is quite sufficient, and that the changes, involving enormously increased cost of construction, recommended by the Board, are unnecessary.

As to the depth of the channels, the company has estimated 28 ft. in the river and 30 ft. in the lake. It has been contemplated that when the plans are finally carried out the depth will be 30 ft. throughout, but in order to open the canal to traffic with no more expense than is necessary to secure free and safe navigation the channels in the river and in the sea-level sections of the canal have been estimated at 28 ft., which is the maximum depth of the deepest ship canal in the world. Attention is called in this connection to an error recently discovered in the quantities of excavation in the upper section of the river estimated for by the company. These quantities were transferred from the government report of 1885 (the government surveys of the river having been used by the company), and it now appears that through clerical error, mistaken computations, or misprint in the preparation of that report the quantities estimated fall short of the actual amount of excavation needed, and it is conceded that the estimates must be corrected accordingly. The computations for excavations in the lake, as on other parts of the canal, were made from data of recent careful surveys made by the company and the amounts inserted in the estimates are believed to be absolutely correct. The discrepancy of 417,000 cu. yds. of dredging in the lake between the amounts estimated by the company and as computed by the Board must be due either to error in calculation by the Board or to distortion of the paper after much handling and exposure of the plans, the figures of the Board being based on scale measurements along 14 miles of excavation. The error in the river section was detected by the Board while checking the quantities in the company's estimates.

Lake Nicaragua to the Pacific.—The company has carefully located two routes for the section of the canal between the lake and the Pacific. The route estimated for involves the construction of a dam about 70 ft. high at La Flor. A deep basin about 5 miles long, created by this dam in the valley of Tola, and three locks to overcome the lake level, extended through the canal to the dam. The alternate route would be wholly in excavation from the lake to Brito, would require four locks of reduced lift, and, while presenting no engineering difficulties its cost would be considerably more than the basin plan, by reason of increased excavation and one additional lock.

Deep borings with the diamond drill, taken at the site of the dam, show that the uniform rock ledge lies at great depth below the surface of the valley, and that the construction of the high dam originally proposed would involve more serious difficulties than had been anticipated. The basin plan is, however, so attractive and presents so many important advantages to navigation, both as a passing place and as an inner, spacious fresh-water harbor, less than four miles from the Pacific, that the company has been reluctant to abandon it in favor of the all-surface route before a more detailed examination of the site has been made, and it is yet confidently expected that in case a high dam proves to be impracticable, one of considerably less height may be safely constructed and the basin plan, with some modifications, retained. Pending final decision in this matter, a temporary earth dam, with concrete core, has been provided for in the company's estimate for the basin-plan route.

The Board regards the result of the borings as conclusive against the high dam, and without giving any consideration to the modified plan with a low-level basin it recommends the low-level canal as the safest. A remarkable change in location is here proposed between the end of the divide cut and Brito, a distance of about eight miles. That portion of the route located by the company, after the most careful detailed surveys and study of the country traversed, with due regard to previous examinations made by the United States surveying expedition, is set aside, and a paper location on the south side of the Rio Grande is suggested and estimated upon in lieu thereof. The claim that the proposed change in location would save complications in disposing of the insignificant water course Tola has no force whatever, as that creek can be taken into the canal or discharged under it into the Rio Grande at small expense and without inconvenience to navigation or risk of injury to the work. The transfer of the canal from the north to the south side of the Rio Grande would involve considerable increased cost in construction and very serious complications in the diversion of the stream by a long, expensive artificial channel, nearly as large as the canal itself, into Brito Harbor between the canal and the high land to the west. It would also prevent the contemplated change in location of the lower locks toward the hills, when more favorable foundations can be found for it, and the diversion of the Rio Grande directly into the sea, should such a plan be found advisable. In fact, to engineers familiar with the project, it is difficult to find one plausible reason to justify the extraordinary change in location proposed for this section of the route.

Brito Harbor.—In the location and design of the harbor of Brito important changes are also proposed by the Board, and with the same disregard for increased cost manifested throughout the report. It is proper to state in this connection that the harbor has been designed with the only object in view of securing an easy and safe entrance to this canal, and not for commercial purposes. The local business at the entrance of the canal is not expected to be large, and in any case the company would not be justified in providing for it, at a largely increased expense, before the need becomes manifest as a business proposition. With the harbor as designed, several ships can be accommodated in it without interference with the traffic through the canal, and the topography of the vicinity presents ample facilities for enlarging the inner basin by dredging, when it becomes requisite and profitable to do so. The Tola Basin, and especially the lake, will be inland harbors, where the attractive surroundings and healthful climate will offer strong inducements for ships to lie at anchor for repairs, for coaling, or to replenish their stock of fresh provisions, with the additional advantage that while lying in fresh waters their bottoms will be cleared of barnacles. For these reasons, large harbors at either terminus, beyond what is actually needed for admission to the canal, are not regarded as necessary or advisable from the start.

The claim of undue exposure is not substantiated by facts. The harbor of San Juan del Sur, about eight miles to the east of Brito, but 600 yds. deep inside of the rocky points forming the bight, comparatively shallow, with a shelving bottom and a sandy beach, and open on its whole width to the south and southwest, is uniformly smooth and affords safe anchorage for ships, hardly a ripple being ever observed on the sandy beach surrounding it. The prevailing winds on that coast are the "papagallos," blowing from north-northeast to east-northeast, directly offshore, frequently with great violence opposite Lakes Managua and Nicaragua, reaching their maximum force in December and January. They are first felt about five or six miles offshore and their influence extends 30 or more miles from the coast. During the rainy season, from May to November, gales from the west and southwest, called "chubassos," are frequent and at times violent, although of very short duration.

The proposed entrance to Brito Harbor is open only to the south and southeast, which are the least exposed quarters; the prevailing swell will be practically arrested by the west breakwater and its deflection into the harbor prevented by the east jetty, and in view of what takes place at San Juan del Sur, there is absolutely no reason to apprehend any undue agitation in the basin or the breaking of the surf on the west beach of the harbor, as feared by the Board; the ground swells break on the shelving, open beach of the coast, but not in deep waters, and as to long, high waves, it is well known that the swells are scarcely noticeable half a mile from the coast, where ships can in ordinary weather lie with perfect comfort.

The statement that the borings made by the company are too few in number and of too little penetration to determine the underlying materials within the harbor limits is not sustained by the facts. Sixty borings were made in the vicinity, and their penetrations were sufficient to show the character of the material to be removed and the outline of the rock ledge within the harbor limits. There is, it is admitted, some important and necessary data yet to be obtained before the final plans for harbor construction can be completed in all details, and to respond to the degree of precision demanded by the Board, but not generally observed in the first estimate for work of this kind.

Cost of Work and Estimates.

In fixing the unit of prices for an estimate of cost of the canal, the Board has been influenced by the controlling impressions received in its hurried trip, made under many difficulties, through a country and in a climate entirely new to it, and has adopted the same extravagant methods and conclusions prevalent throughout the report. The effect of the climate and rainfall in the execution of the works proposed are greatly magnified, and the conclusions arrived at are at variance with practical results attained both by the canal company and by experienced contractors in doing work at Nicaragua.

It is admitted in the report that a sufficient supply of unskilled labor can be obtained from Central America and the West Indies, especially from Jamaica; that under good management the Jamaica negroes are industrious and fairly effective and their wages only about one-half as much as in the United States, but that the efficiency of the laborers is much less in proportion. It is also admitted that under complete police control and subjected to judicious sanitary regulations there will be no more sickness than occurs on public works in many parts of the United States. The Board, however, finds a concurrence of opinion among those who have had experience in the management of construction work in Central America that the cost of work, due to inefficient labor and unfavorable location, is about twice as much as in the United States. Attention is invited in this connection to the practical results accomplished by responsible and experienced contractors who have spent considerable time in Nicaragua at all seasons of the year, and knowing the route of the canal thoroughly constructed 11½ miles of railroad for the company, in order to better study the health of the country and the question of the supply of labor for the construction of the canal.

There can scarcely be a more unhealthful piece of work in the entire canal than that section of the railroad constructed from Greytown 10 miles across the swamps to the higher ground beyond. More than half the men employed worked in the swamps, in water from their knees to their shoulders, ten hours a day, doing hard work, and not always having proper food; and yet out of about 1,000 laborers employed by the contractor for seven months only two died of disease. The men did not stop work on account of the rain, but worked steadily through the rainy season, without protection while at work, except two half days during the seven months, and at the end of that time they were in as good health as at the beginning, or even better. Most of the men were Jamaica negroes, but there were also two or three hundred natives Nicaraguans and Costa Ricans and a few negroes from the United States. The contractors therefore concluded that the matter of health, as affecting the difficulty and cost of construction of the canal, need hardly be considered more than in estimating the cost of work in almost any part of the United States. One party of the contractors had previously had considerable experience in building the railroad from San Jose to Guatemala City, in Central America. They expressed themselves satisfied that a constant force of 15,000 men, or more, could be had on the eastern end of the work from the island of Jamaica alone. These men are good at task work, and are fairly good in large gangs under foremen. A small number of engine drivers, excavators, and steam-drill men, stokers, etc., can be had from the same sources, also a good many rough masons and carpenters.

The cost of the ten miles of road built by these contractors was $32,411.18 per mile, including material, labor, subsistence, and contractors' profits of 10%. The ties and rails were imported from the United States and landed at Greytown under many difficulties and at considerable cost. The actual cost was, therefore, a little over one-half the estimated cost of $60,000 per mile allowed in the company's estimate. That the road was thoroughly built is shown by the fact that, after four years of complete neglect, the work was found by the Board in a remarkably good state of preservation, with the exception of the ties that need renewing. These contractors, with a full knowledge of the country and of all the borings made on the route of the canal, are of the opinion that "the work can be done on the whole canal for about the unit prices estimated by the chief engineer and give the contractors fair profit," and they are ready to contract under bonds to do the work on that basis.

The work done by the company, such as telegraph lines, grubbing and clearing and dredging, has also cost less than the estimate. The dredging was done with an incomplete and, in some respects, unsuitable plant, and its cost, exclusive of deterioration of plant, but including all other charges, was 11 cts. per cu. yd., the estimated cost being 20 cts.

There seems to be no good reason for the statement

that the machinery used will be of but little value after the construction of the canal, that hardly any of it would be worth removal, and its entire cost would therefore be charged to canal construction, making the plant charge higher than usual. With the canal finished and open to traffic and a railroad parallel to it, there is no reason why the plant could not be transported to any part of the world where there may be a demand for it, at the same or less cost of transportation than in the United States.

Unit Prices.

Dredging is being done in the harbor of Mobile to the amount of many million yards, the material deposited 6 miles at sea for 7 cts. per cu. yd., and the contractors appear to be prosperous. In Far Rockaway, where the material has been deposited by pipes as far as 4 miles from the dredges, it costs from 4 to 6 cts. per cu. yd. On the coast of England, dredging at the harbor entrances costs from 5 to 8 cts. per cu. yd. The dredging done by the company in Nicaragua, with an incomplete and unsuitable plant, cost, as has been already stated, 11 cts. per cu. yd. The Board estimates dredging in Nicaragua at 20, 25, and 30 cts., which is not only enormously in excess of the cost elsewhere, as shown above, but also of work actually done in Nicaragua, and at prices at which bids for the work by responsible contractors have been made to the company.

In the earth and rock excavation the company's estimates are from 66 to 78% higher than the cost of similar work at the Chicago Drainage Canal; the Board's estimate is 150% higher. Mr. Thomas A. Edison writes from Orange, N. J., under date Dec. 18, 1895, stating that at his works, at Edison, N. J., with present appliances, the total cost of ore for drilling, blasting, loading and delivery at the crushing plant, including all materials, labor, coal, repairs, etc., is 19.17 cts. per ton (2,240 lbs.), the average distance from the quarry to the mill being about 2,000 ft. The pieces are taken out as large as possible, not to exceed five tons, and he adds that, with the appliances the company is now putting in the cranes for loading the ore into the skips, and with the plant working at full capacity (5,000 tons per 20 hours), he fully expects to deliver the ore at crushing plant for from 12 to 14 cts. per ton, and probably less. The ore weighs about 190 lbs. per cu. ft. The canal rock would weigh from 150 to 160 lbs. per cu. ft., and Mr. Edison thinks that, with the appliances at Edison, N. J., it should be mined, loaded and delivered on the bank for about 25 cts. per cu. yd. On this basis the canal estimate for rock excavation would be from four to five times the actual cost of similar work in this country, and the Board's estimate from five to eight times larger. Mr. Edison says that they blow out several thousand tons at each blast, and try to get the pieces as large as possible, not exceeding 5 tons, as with his appliances a man can load a 5-ton piece as quickly as one weighing 500 lbs.

The same methods should be employed at Nicaragua, and the additional cost of 50 cts. per cu. yd. estimated by the Board for the stone to be used in the rock-fill dam is entirely unnecessary, especially if the rock excavation and the dam are built under one management, as they should be, as it would then be in the interest of the contractor to blow out and select the material suitable for the dam.

Considering that the cost of loading the stone on the cars and of hauling it to the dump are included in cost per cubic yard of excavation, and that the railroad is the property of the company, it seems that the charge of 1 cent per ton per mile for transportation to dam is entirely unreasonable.

The Board's estimate for rock excavation under water is excessive. The rock blasts well, much better than the stratified limestone in the St. Marys River, and there is no reason why the cost of plant in Nicaragua should be 50% greater nor the pay roll double. At any rate, the amount of rock to be removed is large and the plant is simple and comparatively inexpensive. As to the pay roll, it was shown during the progress of the work in Nicaragua that the company could get all the skilled mechanics needed for about the ruling wages in New York, and ordinary mechanics for much less.

The Board estimates concrete at $9.50 per yard, based on the cost of concrete for lock construction at Hennepin Canal. By investigating the subject somewhat further the Board would have found that in the construction of the concrete locks in the Coosa River, Alabama, 20,000 cu. yds. of Portland cement concrete have been laid, and up to the close of the fiscal year ending June 30, 1895, the average cost per cubic yard, including material, labor, engineering, and supervision, has been $4.57 3-10, or about one-half the cost of concrete in the Hennepin Canal locks, used by the Board as the basis for its estimate. Other conditions in this same work are worthy of note in this connection. Portland cement used in the Coosa locks, cost $2.48 per barrel. The best quality can be contracted for free of duty, in Nicaragua, at $1.60 to $1.70 per barrel. The work is done by negro labor, paid for at $1 for a day of eight hours, or 12½ cts. per hour, under climatic conditions more trying than those of Nicaragua. In Nicaragua the negro works ten hours to the day and his wages and cost of subsistence amount to about 85 cts. per day, say 8½ cts. per hour.

Portland cement will be delivered at Nicaragua free of duty, the stone and sand can be had for the cost of transportation over the company's railroad, and as to the effect of rain on the cost of the work, the whole structure can be protected by temporary sheds, and that difficulty entirely obviated. The average price of $6 per cubic yard for concrete in locks in the company's estimate is ample, and responsible contractors in New York are ready to make contracts under bonds to do the work at that price. The prices for metal work, estimated by the company, are too high. The material can be had from Europe and all the work done at less cost than in the United States.

As to the sluices and weirs there is no reason for changing the company's estimates, which are regarded as ample to meet the requirements. It has been stated that the 11½ miles of railroad built by the company through the most difficult portion of the line with insufficient plant and dealing with serious difficulties in landing the material cost at the rate of $32,411.18 per mile. The company has estimated the balance of the road to be built on the east side at $50,000 per mile, including turn-outs, switches, tanks and temporary stations. The Board has estimated for a double-track road at $100,000 per mile, which is not regarded as necessary.

In the western division the company has estimated for a single-track narrow-gage road to conform with the Nicaragua Railroad. The Board estimates for a double-track standard gage railroad, which is not needed for construction work and would be objectionable to the Nicaraguan Government as not conformable to their present system.

It is firmly believed that the company's unit prices for the works proposed are quite sufficient, and that the Board's increased cost of the work is unwarranted and is contradicted by known facts at hand and the fact that responsible contractors familiar with the country and the route of the canal are prepared to enter into contracts for building the whole work at about the company's estimated cost.

THE TENNESSEE CENTENNIAL EXPOSITION.

We have received from the officers of the Tennessee Centennial Exposition a number of illustrated circulars showing the ground plan of the exposition and views of the buildings, several of which are already being erected. The exposition is intended to celebrate the 100th anniversary of the admission of Tennessee into the Union. It is to be held at Nashville, Tenn., beginning May 1, 1897, and will continue six months. The date for opening was originally fixed at Sept. 1, 1896, but it has been changed. The inaugural ceremonies, celebrating the centennial anniversary of the admission of the state will be held on June 1 of this year in the Auditorium Building, which is now well advanced toward completion. The circulars issued by the Department of Promotion and Publicity, Leland Rankin, Chief, give illustrations of the principal buildings. They are all of the classic styles of architecture, and will apparently be more imposing than the buildings of the Atlanta Exposition. A special feature is the Parthenon, which is a reproduction of the Parthenon at Athens. It will be used as the Fine Arts Building. The walls are to be of brick, 2 ft. thick, and the 58 columns are to be of the regular construction for staff covering. One of the circulars contains photographs taken March 14, 1896, of six of the larger buildings, which are far enough advanced to show their complete outlines. They are the Parthenon, the Auditorium, the Commerce, the Machinery, the Transportation and the Women's Buildings.

From a circular issued by Prof. Wm. T. Magruder, Chief of the Machinery Department, we take the following:

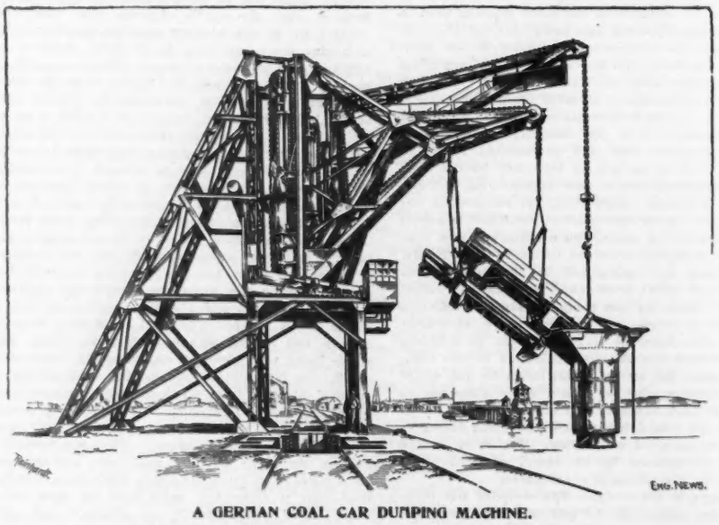
2,500 HP. of boilers will be required to supply steam to the engines and pumps. Engines will be required for driving dynamos for 500 arc lights and for 15,000 incandescent lights, and for driving the machinery exhibits. Small units are to be preferred to excessively large ones. It is hoped that the working exhibits of boilers and engines will include all the usual types. From a suitable reservoir at the south end of Machinery Hall water will be pumped into a tank 12 ft. wide and 48 ft. long, and 54 ft. above the reservoir, and located in the south portico, whence it will flow in a stream over a weir board, the width of which can be adjusted from 48 to 5 ft. This unique feature, together with the electrically illuminated fountains and jets, will enable the pump-makers to fully test and illustrate the capacity of their exhibits. It is proposed to so connect the boilers, engines and pumps, that tests of each unit can be conveniently made if deemed desirable. It is specially desired that as much machinery as possible shall be in active operation during some part of the day.

Application for space should be made at once. There will be no charge for space, but in order that the exhibits may be ready promptly at the opening of the exposition, the board of directors require a forfeit to be deposited when the application for space is granted. Forfeiture money will be deposited with a special trustee, and will not be placed with the general funds of the exposition, but will be returned in full to the exhibitor if the exhibit is ready for inspection on April 29, 1897. The building is under contract to be completed June 1, 1896, so that there will be plenty of time for the selection of space and the installation of exhibits.

Further information concerning the machinery exhibits will be furnished on application by Prof. Magruder. For information concerning other departments address Mr. Leland Rankin, Chief of the Bureau of Promotion and Publicity, Nashville, Tenn.

A GERMAN PLAN FOR COALING VESSELS.

The accompanying cut is a perspective view of a hydraulic crane for coaling steamers, which is in use at Bremen, Germany. The operation of the machine, as shown by the drawing, is as follows: A coal car whose load is to be discharged is run upon a platform which forms part of a track running along the quay wall. The crane then picks up this platform with the car upon it and swings it around until the end of the car is over a huge hopper, which is held suspended over the water from an upper arm on the crane. Then by hoisting on the rear of the car table, it is tilted till the load slides into the hopper. The apparatus is of especial interest in view of the recent installation at some of the Lake Erie ports of car-dumping machines which handle a full-size loaded coal car, a very much greater load, doubtless, than that which is handled by this German crane.



A GERMAN COAL CAR DUMPING MACHINE.

We have redrawn our engraving from a wood cut in a recent German publication, the "Buch der Erfindungen," etc., published by Otto Spamer, of Leipzig, in 1895.

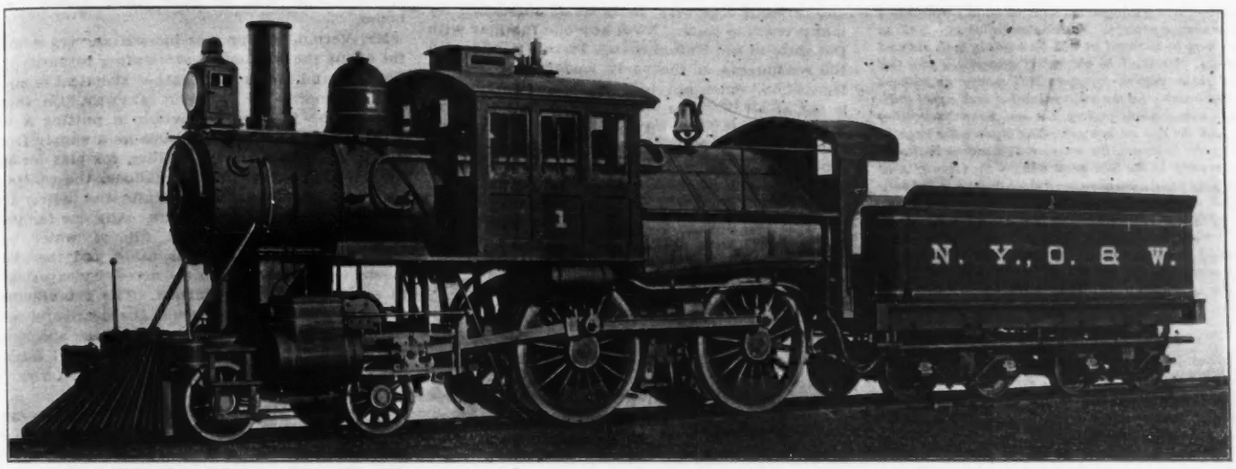
EIGHT-WHEEL PASSENGER LOCOMOTIVE; NEW YORK, ONTARIO & WESTERN RY.

In many of the discussions as to the power of locomotives, and particularly as to the comparative power of simple and compound locomotives, considerable prominence has been given to the question of boiler pressure, and the increase in efficiency and economy of operation due to increased pressure both in simple and compound locomotives. The engine which we illustrate this week was designed and built in order to practically demonstrate whether an engine of this weight in passenger service, with cylinders 17×24 ins. and a constant boiler pressure of 180 lbs., would not be better than one with cylinders 18×24 ins., lagging for steam on the heavy grades. It was intended, also, to demonstrate whether such an engine could not be run at a much reduced cost for fuel. The engine was designed by Mr. George W. West, Superintendent of Motive Power of the New York, Ontario & Western Ry., and was built by the Cooke Locomotive & Machine Co., of Paterson, N J. We are indebted to Mr. West and to the builders for the information used in this article.

The engine has been in constant service since Nov. 23, 1895, and has met the highest expectations of its designer. The same train is hauled on alternate days by this engine, and one with cylinders 18×24 ins., which was designed specially for burning lump anthracite coal, and the difference in cost of fuel is over 2 cts. per mile in favor of the former. Mr. West considers it to be as nearly a perfect engine as can be built for burning cheap fuel, and to meet the other conditions that are necessary in passenger service.

This engine is of the eight-wheel type, with Wootten firebox, the rear driving axle being under the firebox. The cab is over the middle of the boiler, and, as is usual in this arrangement, is entered from the front, but it is not often that so good a form of step is provided for the engineman to get up to the bumper beam and running board. On the other hand, the step to reach the tender deck is very high and awkwardly placed. As a matter of fact this is a detail of locomotive fitting in which European practice is superior to American practice, the steps on European engines being usually wide, low down, and closed at the back, so that a man's foot cannot slip through if the step is wet or slippery. The guides are of the two-bar "alligator" pattern, and the coupling or side rods are of I-section, with solid bushed ends. The piston is made with a follower, and has the Stevens piston packing; the piston rod has the railway company's standard metallic packing. The driving axles are of steel and the truck axles of hammered iron, and the driving-wheel tires are of Latrobe steel. The crank pins are all of steel. The firebox is designed for burning fine anthracite coal, and has the crown supported by radial stays. The boiler shell is of carbon steel; the firebox of Shoenberger steel, and the tubes of charcoal iron. The grate is of combined pattern, with rocking bars and water tube, and the ashpan is of cast iron, with plate iron top section. The boiler feed is supplied by two No. 8 Monitor injectors. The Smith triple-exhaust pipe is used, and the smokestack is cylindrical. The fittings include the Leach sanding apparatus, Nathan triple sight-feed lubricators, the Consolidated Company's apparatus for steam heating for the cars, and the Westinghouse-American outside equalized driving-wheel brake. An automatic coupler is attached to the bumper-beam, and the pilot is of wood. The tender has a wooden frame, and is carried on two diamond-frame trucks.

The engine has a very handsome appearance, and it will be noticed that the boiler is set very high, the center line being 8 ft. 6 ins. above the rails. All the bearings are large, and Mr. West states that there has never been any trouble from bearings heating, which is an important fact that will serve to draw attention to the details of the design. The leading dimensions and particulars of the engine are given, in our standard form, in the accompanying table:



EIGHT-WHEEL PASSENGER LOCOMOTIVE; NEW YORK, ONTARIO & WESTERN RY. Geo. W. West, Superintendent of Motive Power. Built by the Cooke Locomotive & Machine Co., Paterson, N. J.

Dimensions of Eight-Wheel Passenger Locomotive; N. Y., O. & W. Ry.

General Description:	
Type of engine	Eight-wheel
Class of traffic	Passenger
Gage of track	4 ft. 8½ ins.
Fuel	Fine anthracite
Simple or compound	Simple
Running Gear:	
Driving wheels, diam	5 ft. 8 ins.
Truck " "	2 " 9 "
Tender " "	2 " 9 "
Driving wheel centers, diam	5 " 2 "
Engine truck	Rigid center
Journals, driving axles	8 × 11¼ ins.
" truck axles	5 × 9 "
" tender axles	4¼ × 8 "
Crank pins, main journal	5¼ × 4½ "
" side rod journals	4 × 3½ "
Driving axles, diameter	8 "
Truck axles, "	5 "
Wheel Base:	
Driving	8 ft. 6 ins.
Truck	6 " 0 "
Total engine	23 " 1 "
" tender	15 " 8 "
" engine and tender	47 " 2 "
Center of truck pin to center of leading driver	11 " 7 "
Wheels having blind tires	All flanged
Weight in Working Order:	
On driving wheels	76,000 lbs.
On truck wheels	34,000 "
Engine, total	110,000 "
Tender, "	80,000 "
Engine and tender, loaded	190,000 "
Tender, empty	36,750 "
Of full coal capacity (6 tons)	12,000 "
Of full water capacity of tank (3,750 gallons)	31,250 "
Allowed for water in boiler	9,000 "
Cylinders	17 × 24 ins.
Distance center to center	6 ft. 7 ins.
" center to valve face	3 "
Piston rod (hammered iron), diam	3¼ "
Form of crosshead and guides	Alligator, two-bar
Connecting rod, length between centers	7 ft. 8 11-16 ins.
Valve Gear:	
Type	Stephenson link motion
Ports, steam	1½ × 15½ ins.
" exhaust	3 × 15½ "
Slide valves	Richardson balanced
" " lap, outside	13-16 in.
" " lead	1-32 "
" " max. travel	5¾ ins.
Boiler:	
Type	Straight top
Diam. of barrel inside	4 ft. 7 ins.
Thickness of barrel plates	½ in.
Thickness of smokebox tube plate	½ "
Height from rail to center line	8 ft. 6½ ins.
Length of smokebox	5 " 2 "
Working steam pressure	180 lbs.
Firebox:	
Type	Wootten
Length inside	9 ft. 0 ins.
Width inside	7 " 0 "
Depth at front	3 " 8½ "
Depth at back	3 " 3½ "
Thickness of side plates	5-16 in.
" back plate	7-16 "
" crown sheet	⅜ "
" tube sheet	½ "
Grate area	63 sq. ft.
Staybolts, diam	⅝ and 1 in.
" pitch	not less than 4 ins.
Water space, width, front, 4 ins.; sides, 3 ins.; back,	3½ ins.
Tubes.—Material, iron	Number 197
Pitch	2⅜ ins.
Diam. inside 1¾ ins.; outside	2 ins.
Thickness	No. 11
Length between tube plates	11 ft. 6 ins.
Total fire area of tube openings	3.28 sq. ft.
Heating Surface:	
Ratio to grate area	21 to 1
Ratio of ext. tube area to firebox heat. surf.	9.13 to 1
	9.13 to 1
Tubes, exterior 1,187 sq. ft.; interior	1,036 sq. ft.
Firebox	130 " "
Total with exterior tube area	1,317 " "
Total with interior tube area	1,166 " "
Miscellaneous:	
Exhaust	Smith triple exhaust pipe
Smokestack, smallest diam	16 ins.
Smokestack, height from rail to top	14 ft. 11 "
Capacity of tank	3,750 gallons
Capacity of coal space (6 tons)	12,000 lbs.
Brake fittings	Westinghouse-American
Total tractive force with effect. press. = 4-5 of boiler pressure (140 lbs)	14,280 lbs.
Total adhesive tractive power, at ¼ of weight on drivers	19,000 "

STEALING ELECTRICITY is said to have been practiced by about half a dozen saloon-keepers in Brooklyn. The feed wires of an electric car line were tapped for the purpose; and wires were led into the building, supplying incandescent lamps which were placed in series. The stealing was discovered by an electrician who noticed that the lamps showed the same fluctuations of light that are frequently seen in electric lighted trolley cars. It was further proved by unscrewing one of the lamps in the saloon, when other lights also went out, showing that they were connected in series, and not in parallel as is usual in the ordinary incandescent circuits. The final test was made by shutting off for a short time the current from the railway power house, when the cars on the railway stopped, and their lights went out, as did those of the saloon. On turning on the current again the lamps in the saloon and in the cars were lighted and the cars went on. The wires were then traced from the feed wires of the railway circuit along the branches of a tree and the poles of an awning. Several other saloon-keepers are said to have secured current in the same way. One of them has been arrested, and he claims that a man representing himself to be an agent of an electric lighting company put in the wires and lamps, charging him $40 for them, and had since collected $29 for a month's lighting, for which the market price would be $60.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Published every Thursday at Tribune Building, New York. Entered at the Post Office, New York, as Second Class Matter.

D. McN. STAUFFER, CHARLES WHITING BAKER.....EDITORS.
WM. KENT, E. E. R. TRATMAN, M. N. BAKER, } ASSOCIATE
CHAS. S. HILL, A. B. GILBERT..... } EDITORS.
CHAS. W. REINHARDT.....CHIEF DRAFTSMAN.

GEO. H. FROST, F. P. BURT.....BUSINESS MANAGERS.
ALFRED E. KORNFELL, New York..... } ADVERTISING
F. A. PECKHAM, Chicago..... } REPRESENTATIVES.

PUBLICATION OFFICE.....Tribune Building, New York.
CHICAGO OFFICE.....1636 The Monadnock.

LONDON AGENCIES: { KEGAN PAUL, TRENCH, TRUEBNER & CO. (Limited), Paternoster House, Charing Cross Road; SAMPSON LOW, MARSTON & CO., (Limited), St. Dunstan's House, Fetter Lane.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00; Single copies, 15 cents. To all other countries in the Postal Union, add $2.08 per annum (4 cents per number) to above prices for postage. No club rates allowed. Mailing addresses may be changed at will by sending both old and new address. We shall be obliged if subscribers who fail to receive their papers promptly will notify us without delay. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 326 means that subscription is paid to the 32d week (that is the issue of Aug 6) of the year 1896; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents per line agate measure. Want notices, special rates, see page 22. Rates for standing advertisements sent on request. Changes to standing advertisements must be in hand on Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

On another page of this issue will be found a review of the report of the Board of Engineers appointed by Congress to examine the Nicaragua Canal project. The review is made by Mr. A. G. Menocal, Civil Engineer U. S. N. and Chief Engineer of the Nicaragua Canal. The original report, published in our issue of March 26, and this review should be read together to properly understand the situation in Nicaragua. The necessity for further investigation and surveys at a number of points on the line is admitted by Mr. Menocal; but he contends that, in most places, where such additional engineering work is needed, it will not be actually made use of until the work is in an advanced stage, and hence it can be secured coincidently with the works of construction. The chief point made by Mr. Menocal as to depth and width of channel proposed is that the company's plans are "sufficient," from a commercial point of view, for the traffic expected at the opening of the canal, and that it would be wiser to enlarge as the commercial demands make this enlargement necessary than to build the channel full size at the outset as the Board advises. As to the location of Greytown harbor, it is evident that local politics had almost as much to do with the final choice of site by the canal company as engineering and hydrographical requirements. It appears to us that to overcome any difficulties arising from this source, the diplomat should supplement the work of the engineer; if the United States takes a hand in the enterprise, the jealousies of petty Central American states should be set aside. In the matter of increase of unit prices, which is a main cause of the increase in the estimates of the government board over those of the company's engineers, Mr. Menocal makes an answer that has the merit of being founded on specific cost of similar work in other localities. As to the actual final cost of the canal, the basis on which the two estimates were made up must be considered. The estimate of the company is based upon an avowedly economical plan of operation, and the building of a ship canal which is designed to be "sufficient" for the immediate needs of the traffic which would seek it at the start. The estimate of the government engineers is evidently for a deeper, wider and more fully equipped ship canal, such as few doubt the Nicaragua ship canal should be in time.

A considerable part of Mr. Menocal's review, which we have not reprinted, is devoted to an argument against the recommendation of the Board of Engineers that the government should expend $350,000, and 18 months' time in making more complete surveys on which to base a complete project and final estimates. Mr. Menocal claims that the company has already made sufficient surveys to positively determine the line finally selected to be the most advantageous location, and that its surveys, borings, and data are sufficiently complete to make its estimates reliable and conclusive.

Now, admitting for the sake of argument that Mr. Menocal is correct in this claim, we must still believe that he and Mr. Warner Miller and the other advocates of the canal who have appeared before the House Commerce Committee have made a serious mistake in opposing the additional surveys and examinations recommended by the Board.

We pointed out in a former issue that unless the United States Government took hold of the enterprise it was very likely to be untouched for many years to come. Now, any one familiar with the state of the United States Treasury, and with the sentiments of the party leaders who control legislation, must see that the present Congress is not at all likely to guarantee bonds to the extent of $100,000,000 for this or any other company. Further, it must be remembered that this report, made by a disinterested board of three eminent engineers, will have at least equal weight in the public mind with anything that may be put forth by any one connected with the canal company. What then must be the inevitable conclusion of the layman who, knowing nothing of the merits of the case, examines the reports already presented with unprejudiced mind? He will conclude that not enough is known concerning the enterprise to enable experts to agree, and hence that what ought to be done is to collect sufficient facts to enable a concensus of opinion to be reached as to the best route and method of construction. And this, be it remembered, is practically what the Board of Engineers has recommended.

We repeat, therefore, that even on the supposition that the surveys already made are sufficient to fix the best route and to determine with reasonable accuracy the cost of construction, the wisest plan for those who would further the canal is to support the proposition to make additional surveys and urge the appropriation of a sufficient sum for that purpose at the present session of Congress. The cost of these surveys would be only half of one per cent. of the cost of the canal at the lowest estimate. The demand for progress upon the canal enterprise which comes from the South and from the Pacific coast is a very urgent one; and Congress can certainly make no mistake in providing for its still more thorough examination.

The specifications for a new water supply for Jersey City, outlined in our last issue, contain some features which appear to us to deserve severe criticism. The city asks contractors to submit their own plans and specifications for works capable of supplying 35,000,000 gallons a day, with possible enlargement to 50,000,000 gallons capacity, the contractors to name figures at which they will sell water by the million gallons for a term of years or deliver the works over to the city. Alternative bids are invited on a gravity supply delivered at elevations of 127 and 210 ft., respectively, above mean high tide, and bids are also asked for a filtered supply. The vagueness of the gravity specifications is accounted for by the engineer, Mr. C. C. Vermuele, largely on the ground that the available sources of supply are claimed by private interests, and that too specific requirements might shut out possible bidders, and further, that each contractor would probably "insist upon furnishing his own plans for his own works." We have often commented upon the impossibility of securing real competition along these lines. The vast army of competing contractors for labor and material that has in recent years brought to such low figures the cost of large public works are shut out here, no bids from these men being possible unless they control water rights capable of developing 50,000,000 gallons a day. Moreover, Mr. Vermuele states in the report accompanying his specifications that for the city to make surveys and prepare detailed plans for a supply from any given source would take a year's time, yet the city authorities have proposed to give contractors only a month to prepare their own plans and bids under these specifications. Such a course would mean lump sum estimates made in the dark, except in the case of contractors who had previously made up their figures.

In response, we suppose, to recent agitation for a filtered supply from the present source on account of the less cost and delay which this plan would involve in comparison with a gravity supply, specifications for filtered water by the million gallons were prepared. The filtration specifications may possibly lead some of the advocates of filtration to believe that their wishes are being respected, but it is very doubtful whether these specifications will do more than arouse vain hopes.

Mr. Vermuele expresses himself as very doubtful about the wisdom of attempting to purify the Passaic, and seems to be rather skeptical regarding the merits of filtration, anyway. On these grounds he justifies his action in putting a filtered supply on the same basis as a supply from a gravity source, that is, calling for bids for filtered water by the million gallons, the contractor to put in pumps and conduits and deliver the water into the city's reservoirs. Any one familiar with filtration knows that filtered water has never been supplied on this basis, and therefore no one stands ready with the necessary experience to enter into such a contract. The manufacturers of mechanical filters come the nearest of any class to being able to bid under these specifications, although they only build and sell filters, but they are carefully excluded by the terms of the specifications.

To ask for bids for a filtered water supply under such conditions can be little more than a mere form, and gives good ground for suspicion that the real purpose is to put a permanent quietus on all plans for filtration, while pretending to yield to the public demand for a filtered supply. But more must be said regarding the filtration specifications. Not only is the general plan unlikely to be carried out under the most favorable conditions, but in addition the specifications require bidders to stand ready to make absurd guarantees not possible of fulfilment. Bidders must lay down chemical standards for the character of the filtered water in a number of respects, among them being its contents of chlorine and nitrates, both in parts per million. Chlorine is not affected by filtration and has no significance in this connection. The water to be purified is to be drawn from the foul Passaic, and will be more or less laden with organic matter. Now, the slow sand filtration contemplated by the specifications will increase the nitrates in a polluted water, the ultimate figure depending upon the initial amount of the lower forms of nitrogen, which in turn will change with a variety of conditions, none of which can be predicted 25 years in advance. Such requirements make intelligent bona fide bids practically impossible and render the whole filtration specification farcical.

We have several times referred to the attempts which are being made by the Canadian Society of Civil Engineers to secure powers enabling it to control the practice of civil engineering throughout the Dominion. The printed report of the last annual general meeting contains the discussion which took place upon this question of "Professional Status," and the difficulties of the task which the Society has undertaken are pretty well set forth. It may be of interest to recount what has thus far been done. Some time last year the committee on "Professional Status," sent a confidential circular to the members of the Society asking their opinion of the proposition to have the

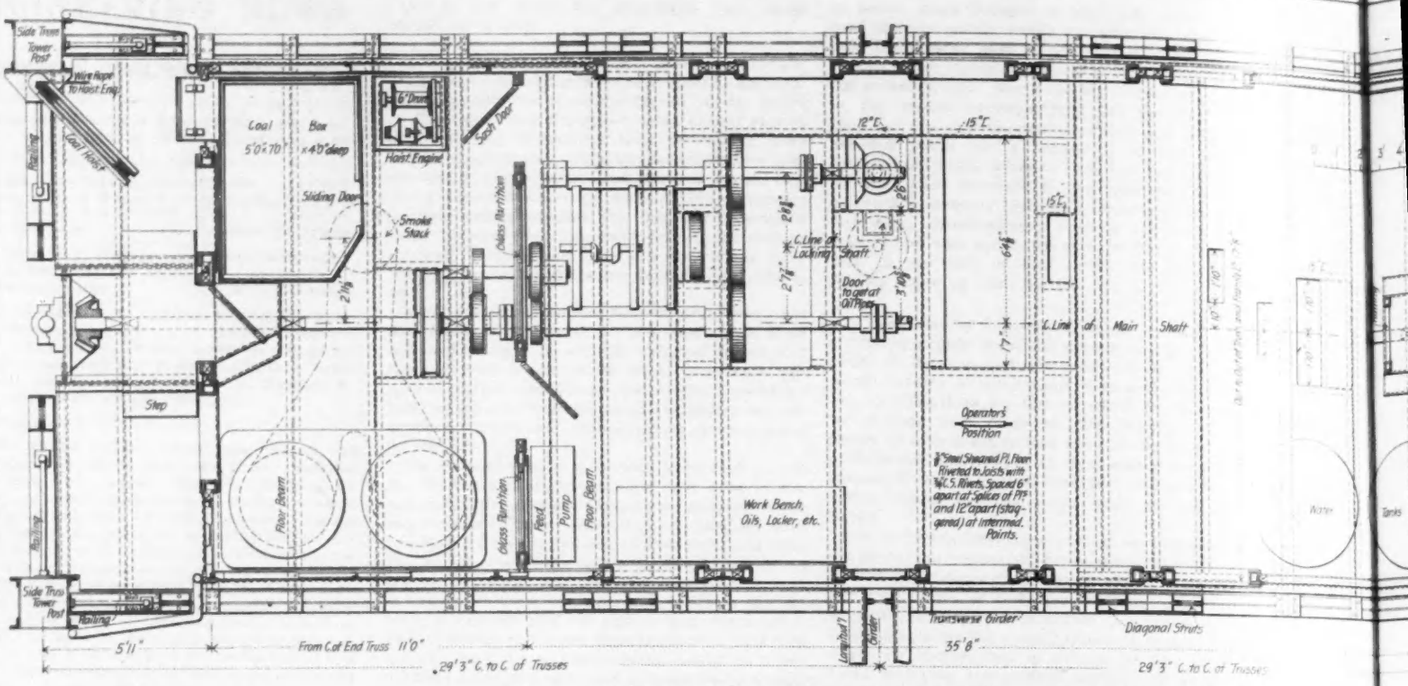


FIG. 1. PLAN OF ENGINE HOUSE SHOWING ARRANGEMENT OF GEARS AND SHAFTING.

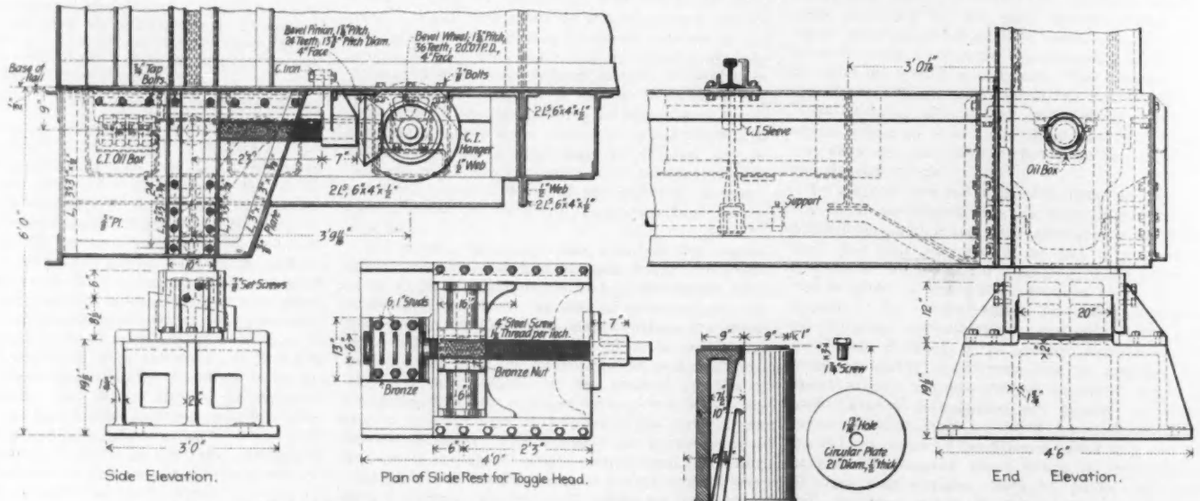
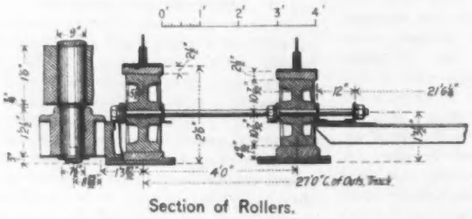
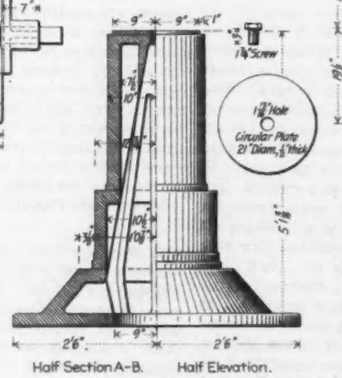


FIG. 6. DETAILS OF LOCKING DEVICE FOR SIDE TRUSSES.





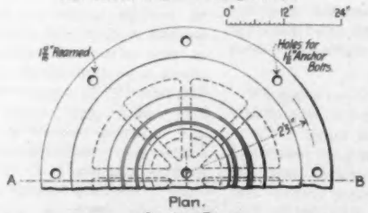


FIG. 3. DETAILS OF CENTER PIVOT AND ROLLERS.

OPERATING MACHINERY FOR HARLEM RIVER SWING BRI

Walter Katte, M. Am. Soc. C. E., Chief Engineer, N. Y. C. & H. R. R. R.

The King Bridge Co., Cleveland

Geo. E. Gifford, M. Am. Soc. C. E., Engineer in Charge for Contractors.

GENERAL
UNIV. OF
2 MAY 1896

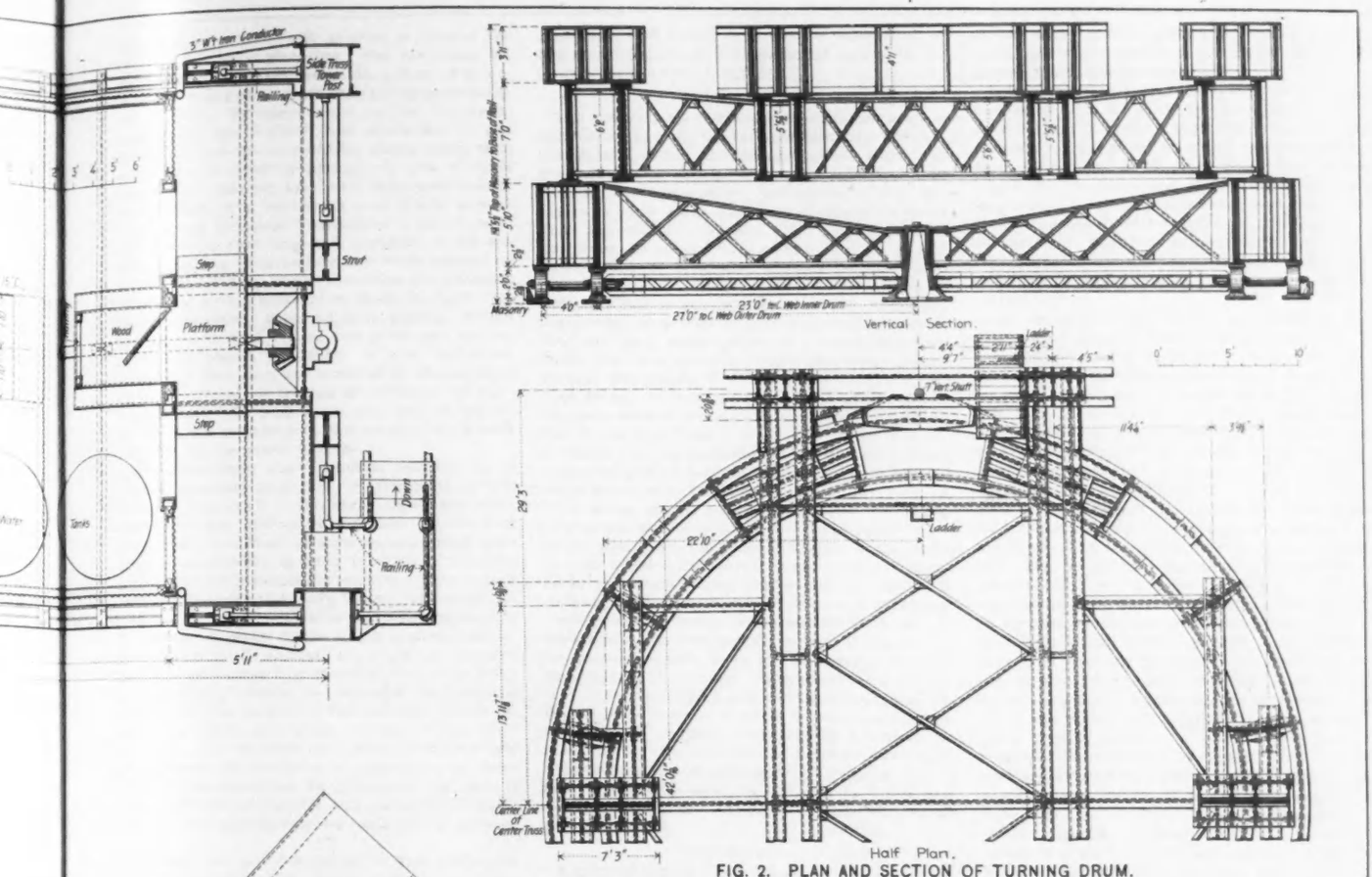


FIG. 2. PLAN AND SECTION OF TURNING DRUM.

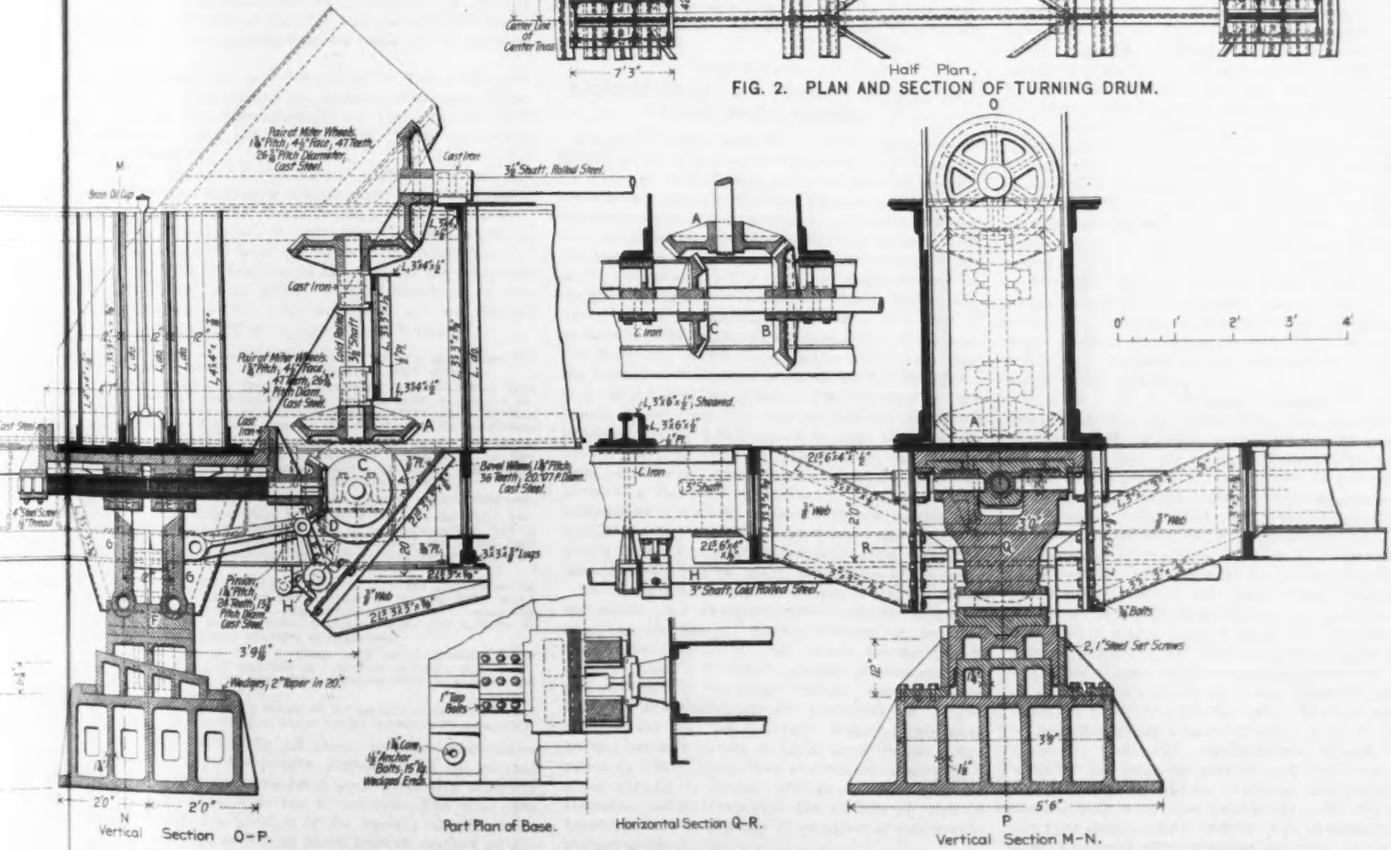


FIG. 5. DETAILS OF LOCKING DEVICE FOR CENTER TRUSS.

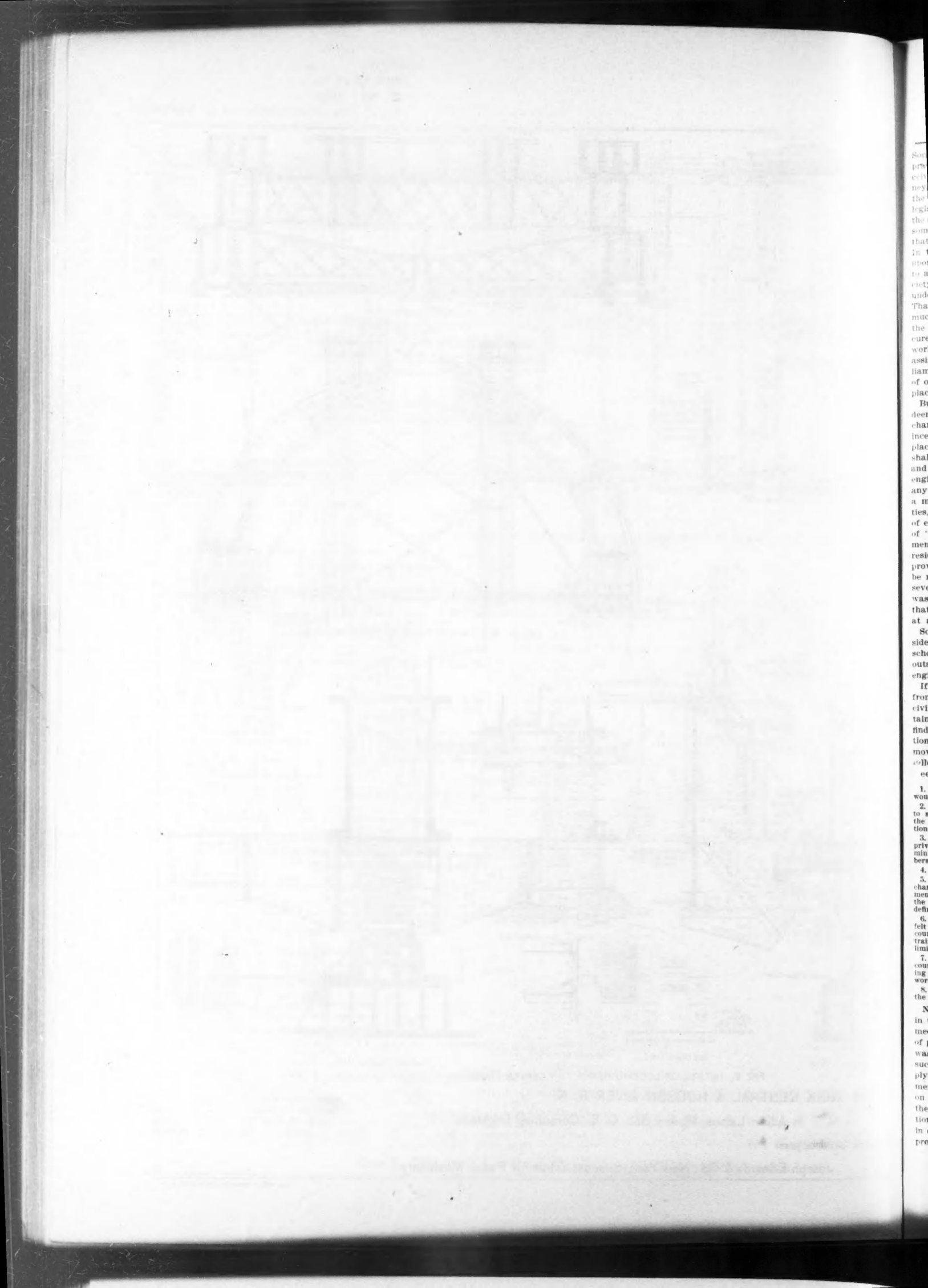
ING BRIDGE, NEW YORK CENTRAL & HUDSON RIVER R. R.

Albert Lucius, M. Am. Soc. C. E., Consulting Engineer.

Cleveland, O., General Contractors.

Joseph Edwards & Co., New York, Subcontractors for Power Machinery.

CHAS. HART & SONS, LITHS., 20 VESEY ST., N. Y.



Society incorporated, with powers to control the practice of civil engineering. The responses received being generally favorable, a firm of attorneys was engaged to draft bills for submission to the Dominion Parliament and to the Provincial legislatures, but when it was attempted to put the scheme into the form of bills which would have some hope of securing passage, it was realized that a very difficult task had been undertaken. In the draft of a bill which was finally settled upon for the Dominion Parliament it was decided to ask merely that none but members of the Society should be employed on any work carried on under the authority of the Dominion Government. That even such a measure is likely to meet with much opposition, goes without saying. Under the present system, one or two good men are secured and placed in charge of any important work, and then they are required to choose their assistants from the friends of members of Parliament, etc. At least such was the statement of one of the members in the debate which took place on the proposed scheme.

But aside from the Dominion charter, it is deemed necessary to secure, or attempt to secure, charters from each of the seven Canadian provinces; and here difficulties multiply. In the first place it will doubtless be a prerequisite that there shall be established in each province a separate and distinct Civil Engineers' Society. Then a civil engineer, in order to qualify himself to practice in any part of the Dominion, would have to become a member of seven distinct and separate societies, subject to the annual fees, rules and by-laws of each. Of course it is possible that some form of "reciprocity" might be arranged, by which a member of the society in the province where he resided would be entitled to practice in any other province. But the time and expense which would be necessary in getting acts passed by all these seven legislatures can be imagined. In fact it was freely stated that, it was exceedingly likely that the proposed legislation could not be secured at all.

So much for the difficulties on the legislative side. On the side of the practical workings of the scheme, the difficulties are no less. At the very outset comes the old question "What is a civil engineer?"

If laws are to be passed forbidding any one from calling himself a civil engineer or practising civil engineering except he be a member of a certain corporation, it will then be necessary to find a definite answer to this long-standing question. The difficulties in the way of the proposed movement were pretty well summed up in the following, which was presented at the annual meeting by Mr. F. J. Lynch, of Ottawa:

1. I do not see that advantages of any great moment would accrue to the profession from such action.

2. Attempts to obtain the necessary legislation may lead to serious disadvantages, by placing civil engineers on the same footing as members of some other close corporations, who can only practice their profession by provinces.

3. I do not think legislation could be obtained binding private corporations or individuals, much less the Dominion or Provincial governments, to employ only members of such a corporation in engineering work.

4. It has not yet been defined what is a civil engineer.

5. Civil engineering is so dovetailed into electrical, mechanical, mining, military and naval engineering, not to mention other kindred professions, that I fail to see how the boundaries covered by a close corporation could be defined.

6. I am not aware that any country has established or felt the necessity for such action as is proposed. Many countries have their own corps of engineers especially trained for public works, but they in no way exclude or limit the general practice of engineers.

7. Supposing such a close corporation formed, other countries might legislate in a similar manner, thus limiting the field for engineers, whereas they now have the world open to them.

8. The financial position of the society does not warrant the large expenditure which would certainly be necessary.

Notwithstanding all these admitted difficulties in the way, the general sentiment at the annual meeting appears to have been distinctly in favor of proceeding with the movement. The final vote was that the Council of the Society should "take such action as it may deem best in respect of applying to the Dominion Parliament for the amendment to the charter presented by the Committee on Professional Status." It was also voted that the Council be requested to take "immediate action," and that it appoint a committee of three in each province to see if the government of the province would pass the proposed bill for civil engineers, and report to a central committee of five members, which is to make its report to the Council before Oct. 1, 1896.

The reason why hydraulic cement mortars are injured by freezing has received but very little investigation, so far as available records show, but it is now pretty generally accepted as a fact that freezing does cause injury, and moreover that this injury is very much less with Portland cements than with natural cements. On another page of this issue we publish the results of some experiments made to determine whether certain chemicals common in cements have anything to do with this loss of strength by freezing. These experiments are worthy of notice because, so far as they go, they seem to prove a very important thing, but they are not nearly extensive enough to bear the weight of the broad conclusions put upon them. In this last feature the chief fault of the experiments lies, as was noted in our issue of Jan. 2, for they show a creditable desire to prove a reason for phenomenon which has to a great extent heretofore been accepted as a fact without much attempt to learn the cause of the fact. A brief study of the results will show, we think, why much weight can not be placed upon them. In the first place the number of tests is too small to give reliable constants from which to work; many engineers would not accept a cement as suitable to the requirements of good engineering work on so few tests. In the second place the results are conflicting enough to cast doubt on the conclusions drawn, even if the number of tests had been much greater. It is possible, of course, that the greater proportion of magnesium is the reason why natural cement is more susceptible to injury by freezing than Portland cement—so many of the ills of hydraulic cements have been hoisted onto the shoulders of magnesium that it is now almost a habit to add thereto every new burden—but these experiments by no means prove the fact.

BACTERIOLOGICAL AND CHEMICAL STUDIES OF PUBLIC WATER SUPPLIES.

The exact status and value of a bacteriological examination of water is not generally understood by water-works officials, and still less so by city councilmen, mayors and the general public. The impression has got abroad that a sample of water may be given to a bacteriologist and that he will shortly be able to say whether it contains typhoid germs and settle once for all its safety or danger for drinking purposes. Such views are likely to be accompanied with the idea that if bacteriology is employed, chemistry is not needed. The facts are, as we stated a few weeks ago, that the isolation of typhoid germs from natural water is a very uncertain thing. Bacteriology is the means to be employed, but as yet the processes involved are so delicate and so long that from a broad, practical point of view it is not safe to say that because the bacteriologist does not find the germ it is therefore not present. To this may be added that if it could be known that a sample collected one day contained no disease germs there would be from this alone no reason for believing that it would not be laden with them the next.

These statements may seem sweeping, but there are times when sweeping statements are not only true but necessary. Bacteriologists of reputation are not likely to lead people astray, but it is easy to learn to count colonies of bacteria and not difficult to recognize certain species, hence amateur bacteriologists are springing up by the hundred all over the country. Many of this class do not hesitate to say in short order whether typhoid or other germs are present or absent in a given sample of water. Within a few months an Indiana "doctor" reported the finding of typhoid bacilli in 12 out of some 15 samples of water submtited to him.

Finding, or claiming to find, the germ may do little harm further than to scare a community and afterward to lessen its confidence in bacteriologists; but when one of these "experts" solemnly and pompously declares that he has carefully examined the water and has failed to find the bacillus typhi abdominalis, fears may be set at rest which should instead be roused to the utmost, and the result is a continued use of dangerous if not deadly water.

Let it not be assumed, however, that the bacteriologist is of no use. On the contrary, his researches are of great value when taken in conjunction with the work of the chemist, each, in fact, supplementing the other. There may be cases where only one is needed, evidence of sewage contamination or its opposite being conclusive from the researches of either one alone. In fact, so far as danger to health is concerned, the services of either may be entirely unnecessary in considering mountain sources of water supplies in sparsely-settled regions.

Let us assume that a city is searching for a new water supply. The engineer employed will reject some sources as polluted, and class others as perfectly safe without consulting either chemist or bacteriologist. A mere physical examination and knowledge of the drainage area and its surroundings is often sufficient to settle the question of pollution or of objectionable turbidity. But there are other questions than pollution or turbidity. The water may contain some mineral salts which render it unsuitable for either domestic or manufacturing purposes. The chemist will settle this. If there are questions as to whether the water is polluted, owing to uncertainties regarding dilution, currents or tides, then both the chemist and the bacteriologist may well be called in, though sometimes either one alone might remove the doubt. The chemist would look for high chlorines and nitrogens; the chlorines to be compared with the normal chlorine, and if high to be regarded as sure evidence of sewage pollution; the nitrogen indicating organic matter of some sort in greater or less quantity, and its relative quantities, as albuminoid and free ammonias, nitrites and nitrates, indicating to some extent the character of the organic matter, and especially the recentness of its admission to the water. The bacteriologist would look first for numbers of bacteria and next for their kind. Bacteria cannot exist without food, and as they live on organic matter, their presence in large numbers indicate probable pollution. A study of species would throw light upon the source of the organic matter, and if bacteria common to sewage abounded, it would be inferred that typhoid germs were likely to be present, even if the most painstaking research failed to disclose them. The combined effort of the chemist and bacteriologist, added to the existing knowledge regarding actual or probable pollution, would form a basis for a sound conclusion regarding the fitness of the water for human consumption. Of course, the same general principles as have just been outlined apply equally to an old source of supply suspected of pollution.

Coming next to a polluted supply which has been subjected to purification, the chemist or bacteriologist, or both, would be needed here in accordance with the objects designed to be effected by the plant. If clarification or the removal of iron, vegetable stains or softening was the desideratum, then the chemist would be employed; if harmful bacteria, then the bacteriologist; if a combination of bacteria with some of the above, then both scientists would be in requisition. A moment's reflection will make plain that only bacterial determinations would be necessary in the case of water treated on account of previous sewage pollution, for obviously the water would not be tolerated if the sewage was present in sufficient quantities to be in itself harmful, so the object is to remove the bacteria. If these are all, or practically all, removed, what more could be desired? Chemical examinations would show whether the organic matter had been removed, and if it had would be a strong indication that the bacteria were also done away with, for without food death comes swiftly; but nowithstanding this, bacterial examinations are the most conclusive. If mechanical filtration were the process in use, the chemist might perform valuable service in determining the chemical character of the water and the amount, and possibly the kind of coagulant to be used, the efficiency of alum, for instance, depending upon the carbonate of lime present.

From all that has preceded, it is evident that here, as elsewhere, no hard and fast rule can be laid down regarding the course to be pursued. An engineer having to do with water supplies should be sufficiently well informed to decide whether to call upon a chemist or bacteriologist or both in a given case. If the matter is up for decision by water-works superintendents, commissioners or other city officials not familiar with the matter in hand, then advice should be sought from a competent engineer, or from both a chemist and a bacteriologist, or some unprejudiced person of one of these classes who will not hesitate to call in a worker from the other field, if needed. We say unprejudiced, because there are some workers in both lines who do not give due credit to those outside their line of investigation and urge that their own branch of study is sufficient. Happily there are specialists in water examination and purification who combine a knowledge of bacteriology and chemistry, or maintain relations with others that enables them to bring both methods of investigation to bear upon a case when necessary.

Some points relating to the subject under discussion are well brought out by Prof. W. P. Mason, of Troy, N. Y., in a brief article which appeared in the "Journal of the American Chemical Society" for February, 1896, and has since been reprinted for private circulation. Professor Mason cites an instance where water into which a large number of typhoid germs had been directly introduced, was submitted to both chemists and bacteriologists for examniation. As the water contained no organic matter, the chemists declared it pure, while, as it contained pure cultures of typhoid germs in large numbers, the bacteriologist had no difficulty in finding them. Of course such conditions do not occur in actual practice. Professor Mason concludes his admirable little paper as follows:

> It is very far from my desire to decry the value of bacteriology, but I cannot but feel that in their enthusiasm over the great triumphs of the new science, the people at large have gone slightly "bacteria mad," and are apt to expect more than can be furnished by the means and information now available.

"Bacteria mad" expresses well the craze which has been sweeping over the country in the last few years. The popular mind has been affected by the wonderful developments of bacteriology much as it has by the marvels of electricity. These new sciences have been thrust upon the public much faster than they could be grasped, with the result that all sorts of absurd possibilities are popularly believed regarding them. A magic charm seems to go with the words electricity and bacteriology alike, filling the public with hopes and beliefs, many of which are equally groundless. It is the province of the engineer and of certain public officials, whether engineers or otherwise, to rectify some of these misconceptions and, in the case of public water supplies, to teach that all sewage-polluted water is dangerous, and that no pains should be spared to detect and prevent pollution, to seek sources above reproach, or when these are not available, to make use of the recent advances in water purification.

LETTERS TO THE EDITOR.

The Deflection of a Steel Beam When Heated

Sir: In an article on "The Art of Fireproofing," on p. 235 of your issue of April 9, the writer, in showing the effect of the elongation of the lower flange of a steel beam, calculates the deflection (d) of the beam thus:

$$d = \sqrt{120.092^2 - 120} = \sqrt{22} = 4.7 \text{ ins.}$$

This is a manifest misprint and should read:

$$d = \sqrt{120.092^2 - 120^2} = \sqrt{22} = 4.7 \text{ ins.}$$

He does not give the depth of his beam in figures, though by the drawing it seems to be, say 22 inches, but the point I wish to make is that no beam of a depth allowed by any building laws would deflect 4.7 ins. in 20 ft. from an uneven heating of 100° F.

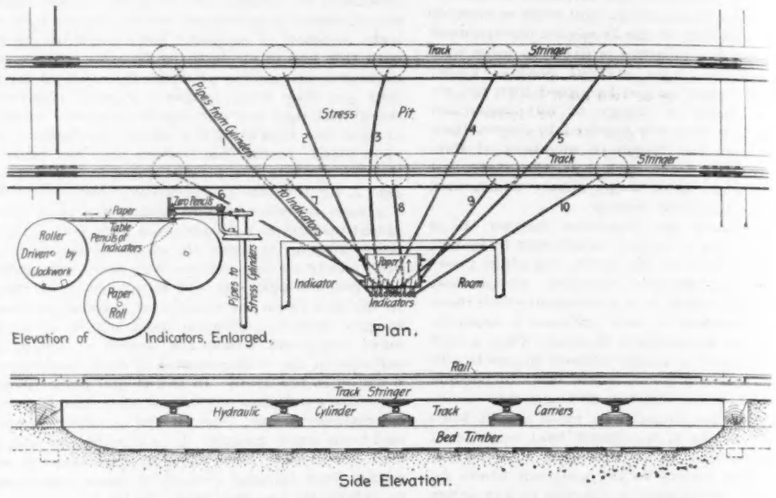
The deflection statement is enough to destroy the effect of any reasoning, however good, based upon such an assumption. If the decimal point were removed one place to the left, it would make the result nearer to nature, with a beam of the depth shown in the sketch. The bending of a 20-in. beam, due to the elongation of 3-16 in., gives a radius of curvature, in round numbers, of 24,000 ins., and a versed sine of 0.3 in., which would be about the deflection due to the heating as assumed, instead of 4.7 ins.

J.

New York, April 14, 1896.

Weighing Moving Trains.

Sir: The discussions on the subject of bridge strains show that engineers are not agreed either as to the amount of variation from static weight or the effect of synchronous oscillations on panels or bridges. The writer respectfully offers the following suggestion of methods for the determination of some of these unknown quantities, and the accompanying sketches will illustrate them, and for more concise description they will be regarded as already built:



A PROPOSED DEVICE FOR WEIGHING STRESSES CAUSED BY MOVING TRAINS.

The stress pit is constructed in a side track so far from a station as to permit of the train passing it at any desired speed. It consists of heavy longitudinal stringers, bedded so that their tops are some 14 ins. below the bottom of the track stringers which span an opening long enough to represent a bridge panel. In this opening are placed a number of hydraulic cylinders or disks, communicating by small pipes with a similar number of indicators recording stresses by means of the hydraulic pressure resulting from the passage of a train over the disks. The shorter pipes may be coiled or otherwise lengthened so that all shall be of equal length; although, as the hydraulic impulse travels probably more than a mile per second, this may not be important.

The paper, a wide sheet, receives the record of all the indicators simultaneously; and a set of zero pencils trace zero lines at the same time. In addition to these, points are dotted by the clockwork on the moving paper at every second, by which the time of the train's passage is determined, thereby recording its speed.

A camera, properly placed, takes an instantaneous side view of the train, which identifies each engine and car; the panel being long enough to more than cover the revolutions of a driving wheel, the variations made by the balancing of the wheel will be shown, and from these data the action may be predicted for any length of bridge.

To find the effect on the main members of a truss place a single (large) hydraulic disk or cylinder under one of the feet of the truss. Should it not be practicable to make it large enough to give pressure within the reach of the indicator, a reducing device can be added as indicated on the left. This will reduce the pressure to any proportion or amount desired. Such a device would give all variations of load on the truss during the passage of a train, as also any synchronous movement, and the effect of wind strains.

To operate the panel device, a tank is placed at the height necessary to balance the weight of the track system by hydraulic pressure and when so balanced the feed pipes are closed, leaving them open to the indicators only; these latter may be placed at the level of the tank, or below, as the zero pencils can be adjusted to the indicator pencils. The movement of the cylinders under pressure is too small to be measurable, therefore no allowance need be made for any bending moment between the pit and solid track. A moment before the train reaches the pit, the operator starts the clockwork, and stops it when the train has passed; the paper will now be found to have received a full record of the passage of every separate wheel of the train, from which may be deduced the strains for a bridge of any length.

To avoid danger of leakage by pistons, a corrugated copper disk is used instead, and indicators of the flattened tube type; this arrangement assuring no loss of water with consequent descent of the disks during the passage of a train. Further description is probably unnecessary, and any ideas which this may convey are at the service of the profession.

G. W. Pearsons.

Kansas City, Mo., Feb. 10, 1896.

La Rue's Formula for Curvature of Chords in Bridge Trusses.

Sir: Referring to the paper, "A New Formula for the Curvature of Chords in Truss Bridges," in your issue of March 19, the statement of Mr. La Rue that "Live load tension will occur in a vertical post when the truss is fully loaded, if at all," is erroneous, as may be seen by the following simple investigation. The notation is explained by the accompanying sketch. For the left-hand reaction we have

$$R = \frac{W_1 x_1}{l} + \frac{W_2 x_2}{l} \qquad (1)$$

Then the stress in post P_3 will be

$$P_3 = \frac{R(l+s) - W_2(s + x_2)}{s + m d} \qquad (2)$$

Substituting in equation (2) the value of R from (1) we get

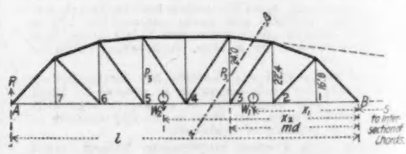
$$P_3 = \frac{W_1 x_1 (l+s) - W_2 s (l - x_2)}{l\ m d + s)} \qquad (3)$$

Since $l > x_2$ the loads W_1 and W_2 produce stresses of opposite kinds in post P_3. Consequently for all cases in which the intersection of the top and bottom chords affected by the section $\alpha - \beta$ lies outside of the supports A and B, a partial loading represented by W_2 produces the maximum compression and a partial loading represented by W_1 produces the maximum tension in post P_3. Should the point of intersection fall inside the supports A and B, formula (3) becomes

$$P_3 = \frac{W_1 x_1 (l+s) + W_2 s (l - x_2)}{l(m d + s)}$$

and therefore a full loading of the truss will produce maximum tension in the post P_3.

The above general statement can be verified by figuring the stress in post P_3 in the example given by Mr.



La Rue: Loading panel points 1, 2 and 3 only by a load W, we get by substituting the proper numerical values from equation (1) $R = \frac{3}{4} W$ and from (2)

$$P_3 = \frac{\frac{3}{4} W \times 20}{15} = W;$$

or, in other words, a tension equal to one panel load

By loading panel points 4, 5, 6 and 7 only, we get from equation (1) $R = \frac{1}{4} W$ and from equation (2)

$$P_3 = \frac{\frac{20 \times 11}{4} W - 70 W}{15} = -W$$

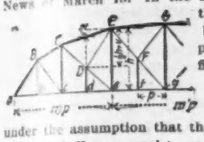
or a compression equal to one panel load. For full loading by a uniform load the tension equals the compression in amount, and hence the stress in post P_3 will be zero, as stated by Mr. La Rue.

Yours truly,

Henry Szlapka, C. E.

761 E. State St., Trenton, N. J.

Sir: I cannot commend too highly the practical utility of the formulae for the curvature of chords in truss bridges proposed by Mr. Benj. F. La Rue in Engineering News of March 19. In the case of the half-hitch truss



the formula seems to have been slightly "mixed" by the printer, and I supposed at first that it was

$$v = \frac{h\,(m^1 - m)}{m\,m^1 + 2}$$

under the assumption that the vertical component of the stress in D E was equal to one-half of a panel load. This, however, is incorrect, the said vertical component being $\frac{\frac{1}{2}\,h + v}{h}$ of a panel load.

Using Mr. La Rue's notation we have,

$$R = \frac{W\,(m + m^1 - 1)}{2},$$

$$H = \frac{R\,m\,p - W\,(m-2)\,\frac{1}{2}\,p\,(m+1)}{h} = \frac{W\,p\,(m\,m^1 + 2)}{2\,h},$$

$$V = H \times \frac{v}{p} = \frac{W\,v\,(m\,m^1 + 2)}{2\,h}.$$

In panel d e, $S = W\left\{\frac{m + m^1 - 1}{2} - (m-1)\right\} = W\,\frac{m^1 - m + 1}{2}$.

Following Mr. La Rue's reasoning, the limit of inclination of chord is when stress in vertical post E e is zero. The vertical component in D e will then be one panel load. Hence the shear in the panel, $S = V + W - \frac{\frac{1}{2}\,h + v}{h}\,w$, or,

$$V = S - W + \frac{\frac{1}{2}\,h + v}{h}\,W = W\left\{\frac{m^1 - m - 1}{2} + \frac{\frac{1}{2}\,h + v}{h}\right\}.$$

Equating the two values of V we have,

$$\frac{W\,v\,(m\,m^1 + 2)}{2\,h} = W\left\{\frac{m^1 - m - 1}{2} + \frac{\frac{1}{2}\,h + v}{h}\right\},$$

$$v = \frac{h\,(m^1 - m)}{m\,m^1}.$$

The total rise in C E is equal to 2v. It will be seen that this formula is strictly correct, and is simpler than the approximate form given above.

Yours truly,
R. C. Berkeley, Jr.

1122 Monadnock Block, Chicago, Ill., April 2, 1896.

(Besides the above letters we have also received a letter from Mr. C. W. Hudson, of Phoenixville, Pa., making substantially the same criticism of Mr. La Rue's article as that made above by Mr. Szlapka. We have submitted all the above letters to Mr. La Rue, and append his reply as follows.—Ed.)

Sir: Referring to the letters of Mr. Henry Szlapka and Mr. C. W. Hudson, criticising my statement that "Live load tension will occur in a vertical post when the truss is fully loaded, if at all," I would say that the statement was an error. The possible tension in a post, due to a partial load, however, is materially less than given by Mr. Szlapka's equations. Referring to his sketch, Mr. Szlapka states that the stress in P_2 will be given by his equation (2). This statement is very considerably in error for a truss having counter ties. That equation represents the total vertical shear sustained by all web members cut by the plane $\alpha - \beta$, which would ordinarily be two counter ties and a post. The counter ties, though mentioned in the writer's article and clearly shown in the sketch accompanying it, are omitted by Mr. Szlapka. They are used in Pratt trusses to provide for the condition of load discussed by him and their omission materially changes the stresses in the posts.

As the chord is horizontal in the panel 3-4, the amount of shear sustained by the counter in that panel, with panel points 1, 2 and 3 only loaded, will be equal to the reaction = ¾ W, while the shear sustained by the counter in the panel 2-3 will be equal to $\frac{\frac{3}{4}\,W \times 20 - W \times 15}{14} = 0$. Hence, instead of there being tension equal to one panel load in the post P_2, as stated by Mr. Szlapka, one-fourth panel load only will be taken by this post as tensile stress. Whether tension will actually occur in the post will depend upon whether the tensile stress will be sufficient to overcome the initial compression produced by adjusting the counters. The conditions of initial stress will, of course, be present also when the truss is fully loaded and, therefore, does not affect the error in my statement quoted above. In Mr. Hudson's criticism, the effect of the counter ties is mentioned.

In reply to the letter of Mr. R. C. Berkeley, Jr, regarding the formula for the curvature of chords in half-hitch trusses, I desire to state that the formula $v = \frac{h\,(m'-m)}{m\,m'}$ as derived by him, correctly represents the conditions assumed. In this form the formula was originally derived by me, but in order to reduce the curvature sufficiently to give a vertical component equal to 1½ panel loads in the upper portion of the main tie, I afterward modified it to the form $v = \frac{h\,(m'-m)}{m\,m' + 2}$, in which form it was given in my article, though somewhat transposed by the printer. As the derivation of the formula was not given, I did not deem it essential to call attention to the modification. The designer can use either form for this formula, knowing that when the form $v = \frac{h\,(m'-m)}{m\,m'}$ is used, the vertical component of the dead load stress in the upper half of the main tie will always be equal to $W\left[1\tfrac{1}{2} - \frac{v}{h}\right]$, while when the form $v = \frac{h\,(m'-m)}{m\,m' + 2}$ is employed, this vertical component will always be equal to 1½ W, and there will be compression in the post equal to $\frac{Wv}{h}$.

Yours very truly, Benj. F. La Rue.

Coal Exchange, Scranton, Pa., April 8, 1896.

The Evolution of Dredging Machinery.

Sir: It is the writer's opinion that a little history will throw considerable light on the subject of the cause of difference between the dredging machinery used in this country and in England.

As in the case of railway equipment, the marked difference in development cannot be entirely attributed to difference of conditions or environment, but to a fundamental difference in the first conception of the machine and the persistent working of inventors or designers in different lines on the opposite sides of the Atlantic; also to a seeming hereditary tendency in the English mind to stick to the English method no matter how much better others may be.

The following sketch of the early history of the dredge shows very plainly that from the beginning the English machine has been of the endless chain and bucket type. The clam-shell digger is used in confined localities for soft excavation and lately the hydraulic machine, but not the dipper or scoop dredge, which is purely an American invention, and has proved of great value in materials of all kinds and in all localities except the most exposed (such as sea bars, etc.).

In Weale's papers on engineering and kindred subjects (1843) there is a notice of a book by Verantius bearing the date 1591, in which there is a description of a dredge consisting of two pontoons lashed together, with two spoons working in opposite directions between them, by means of a walking wheel, the raised material falling into a hopper barge. This was considered the earliest form of the primitive dredging machine.

*In 1718 a machine worked by steam was invented by Savery for raising ballast or gravel from the bed of the river. A book published in 1685 by Cornelius Meyer, a Dutch engineer, describes a dredge, worked by horse power, which raised mud through a trough by means of boards. Canals and harbors were cleaned out with it.

Weale gives the time of the introduction of dredging in Great Britain as the early portion of the 17th century, during the reign of Charles I., when some Dutch engineers undertook the improvement of the great Bedford level. *Hertel mentions a machine tried at Amsterdam in 1708 called "muder mole" or mud machine (Weale). Another machine invented about this time, consisted of a vertical wheel, working between two pontoons, with six buckets attached to the circumference, which could be raised or lowered by screws.

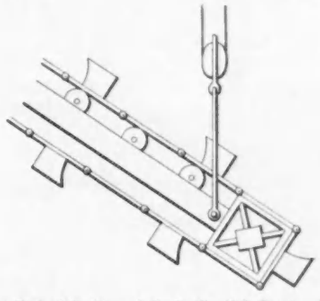
In 1768 the improvement of the Clyde gave a considerable impetus to the development of dredging apparatus, as the conditions involved in the work on that river necessitated principally artificial methods for deepening the channel. Dredging had not advanced, though, to any degree of efficiency until after the more general introduction of the steam engine at the beginning of the 19th century. In 1747 an endless chain and iron bucket machine was invented by Lonce and was used in the port of Dieppe on the north coast of France, and at the Orleans bridge in 1750 and 1753 under Decressart and Perronet. In 1785 an endless chain and buckets attached to a movable ladder worked by a horse was designed by a Mr. Grundy in England. In 1774 scoop-wheel dredges were designed by Redlykheed, and in 1870, by Ekhardt. These machines were used to advantage in shallow water.

In 1796 (see Webster on dredging appliances) a Mr. Greinshaw, of Sunderland, applied to Messrs. Boulton & Watt for a steam engine to work dredging machinery for the purpose of clearing Sunderland Harbor. The machine was built in the following manner: A 4 HP. engine was placed on a flat-bottom boat 60 ft. long, 20 ft. wide and 6 ft. deep, with a draft of 4 ft. The weight of the engine and other machinery was 23 tons. The capacity was four spoons, each containing 1 ton of material, when full, lifted about 10 ft. per minute. With the exception of the crude machine mentioned by Schonberg as being invented in 1718, this is probably the first steam dredging apparatus ever constructed. The spoons or buckets in this dredge were made in the form of truncated cones with the small end closed, the open end having a spade bit. The spoons were made of hide leather with iron rim. *The engine had a 12½-in. cylinder and 3-ft. stroke, and made 30 strokes per minute.

In 1802 Rennie had in use an endless chain machine with eleven wooden buckets edged with iron, revolving over rollers set at the upper and lower end of a ladder frame. The roller at the upper end was at first connected by wheels to a horse wheel, but in 1804, the horse wheel was replaced by an engine of 6 HP., after which it raised as much as 20,000 tons of mud a year at a cost of about 6 cts. per cu. yd. from a depth of 22 ft.

After 1805, in England the value of the steam dredger became generally known. Weale gives the performance of the bucket ladder machine, at that time, as rarely exceeding 50% of the power expended. This, he states, writing in 1845, arose from the complexity of the machine and the varying nature of the soil. "A good machine should raise from a depth of 25 ft. 150 to 200 tons of gravel per hour about 34 ft., or about 700 to 800 tons per day, or at the rate of 10 tons per HP. per hour."

The accompanying rough sketch shows the general arrangement and form of bucket and ladder in use in 1807-1808.



Lower End of Ladder of Early English Dredge (1807).

At the top there is a rectangular turner similar to that below, and cogwheel connection through which the engine power is transmitted to the dredging machinery. For additional historical notes see Webster on dredging appliances, Proceedings of the Institution of Civil Engineers, July, 1887, Schonberg's paper before mentioned and Weale's magazine.

The writer has been unable to find mention of any complete dredger but the endless chain and bucket type (and the various scrapers, plows, harrows, etc., now rarely employed) in use in early dredging days in England, and it seems clear to his mind that the present dredging practice in that country is influenced to a great extent by that fact.

In railroading, bridge building, etc., the same difference exists and will continue to exist until the natural prejudice and honest (often just) conceit of the British mind has been overcome.

The first use of the dredge in the United States was probably in the construction of canals. Col. Craighill, in his "Improvement of Rivers," states that as late as 1847 in this country there were few dredges, and these of the Osgood pattern (scoop dipper) with accompanying tug and scows. For some time this scoop-dipper dredge was used almost exclusively in this country, but in the last fifteen years dredges of every kind and description have been designed and used, bucket-ladder, clamshell, hydraulic, conveyors, hopper dredges, both hydraulic and ladder, both large and small, each different type, form or pattern being applied where best suited to the work to be performed. At the present time a dredge is in operation on the Mississippi River of the hydraulic type having a capacity of over 3,000 cu. yds. per hour (see Eng. News, April 23, 1896).

Mr. Robinson very truly states that the ordinary American contractor cannot afford to keep up such large machines, for the great variety of work he may have to perform, as the English harbor trusts, which employ them for the one special purpose, for which they were designed. It would be incorrect to attribute the entire cause of difference in dredges to the difference in consistency of material or environment, because undoubtedly the same conditions exist in many places abroad where the dipper (scoop) is employed to great advantage in this country. The cost of dredging varies too greatly in this country with different materials and under different conditions, even with the same machine, to make any comparison of value. With radically different machines under different systems the variance would be still greater.

There is certainly greater loss in power in the bucket

*See paper "Construction and Use of Hopper Dredge," by Alexander Charles Schonberg, A. M. I. C. E., read before the Civil and Mechanical Engineers' Society at the Town Hall, Westminster, March 14, 1888.

*The practicability of draining the great Bedford level was not thought of after the Roman works were destroyed, until 1436, and not undertaken until 1634, being practically accomplished in 1688.—Chambers' Encyclopedia.

*James Watt, of steam engine fame, entered into partnership with Mathew Boulton, proprietor of the Soho Foundry near Birmingham, in 1774. The firm of Boulton & Watt manufactured draining machines of (then) large dimensions, as well as other steam apparatus.

ladder in overcoming the inertia of the machinery per ton raised than in the dipper; the material also is generally raised an unnecessary height in the former dredge, whereas the dipper adjusts its work to the required lift. In the ladder machine Webster gives about 60% as the amount of the total power required to work the machinery, leaving 40% to do the necessary dredging.

In exposed localities, of course, the comparison of the scoop dipper or the purely American type and the bucket ladder, the English machine, is absurd; each has its special purpose and application which good engineering practice should dictate, no matter in what part of the world it is used.

H. St. L. Coppee, M. Am. Soc. C. E.

U. S. Engineer Office, Greenville, Miss., March 26, 1896.

EFFECT OF MAGNESIA ON THE STRENGTH OF CEMENTS WHEN SUBJECTED TO FREEZING.*

By Frank Haas, Dayton, O., and John Alexander McGraw, Columbus, O., Graduates in the Class of 1895, Ohio State University.

It has been observed that cements subjected to low temperatures while setting suffer a loss in

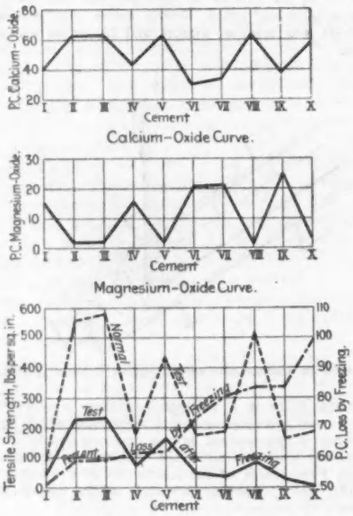


Fig. 1.—Diagram Showing the Relation Between the Tensile Strengths of Portland and Natural Cements Frozen and Unfrozen, and Proportions of Calcium and Magnesium in the Cements.

strength. Experiments have been made to determine means of counteracting this loss, some of which have been successful in furnishing a partial remedy. The great variation of this loss first suggested the idea of seeking the cause in the chemical composition and physical properties of cement, since recent experiment show that differences in mixing fail to explain it. With this end in view ten samples of cement, consisting of five brands of natural cement and five of Portland cement were chosen.

(1) A careful chemical analysis was made to determine the following constituents: pure silica, the oxides of iron and aluminum, lime, magnesia, and the alkalies, or the oxides of sodium and potassium.

(2) Tensile strength tests on each cement were made in parallel at ordinary temperatures, and at freezing temperatures.

The chemical composition of the different brands as determined by analysis is shown in Table I.

All cement was mixed in the test room where the temperature was never over and usually much below 50° F. The mortar was mixed so that a ball 1 in. in diameter if placed on the mixing slab would retain its shape for a minute or so, or when dropped from a height of 2 or 3 ins. would flatten out without cracking the edges of the pat. The proportions of cement and water given in Table II. when thoroughly mixed gave this consistency. This mortar was too thin to admit of any packing into the molds, thus a very uniform set of briquettes was obtained. The briquettes were, however, of a lower tensile strength than would have been the case with a stiffer mortar packed into the molds.

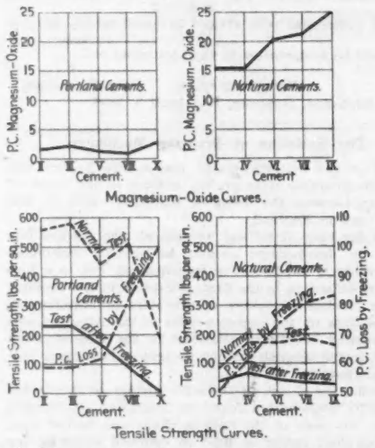


Fig. 2.—Diagrams Showing Separately the Relations Between the Tensile Strengths of Portland and Natural Cements Frozen and Unfrozen, and the Proportions of Magnesium in Them.

The briquettes for the frozen test were treated in the following manner: The molds were first placed outside and allowed to assume the temperature of the outer air (6° to 20° F.). The molds were then brought into the test room to be filled but were again placed outside before the cement began to set. The briquettes remained in the outside air for several hours and were then taken from the molds and placed in tin cans which were taken to the brewery where they were subjected to a temperature of from 8° F. to 10° F. for 7, 14, 21, or 28 days, according to the length of test. At the end of these periods they were returned to the test room, taken from the cans and placed it water at 50° F., where they were allowed to remain for 24 hours before being tested. It will be seen that the briquettes were frozen during the entire time of test. The parallel or normal tests were kept in the test room during the entire time of test, being placed for 24 hours after making on a moist air box, after which they were taken from the molds and placed in water at a temperature of 50° F., where they remained until broken. The testing machine used was one made by Tinius Olsen, Philadelphia, Pa. Metal clips were used for holding the briquettes. A large percentage of breaks made were good.

On examination it was found that the diagrams illustrated were the ones of importance to this investigation, and hence are the only ones which will be discussed here. In the diagram, Fig. 1, the calcium oxide curve shows a tendency to follow in a general way the curve of the freezing tests. The magnesium oxide curve is approximately the inverse of the calcium oxide curve or the freezing strength curve. It will be noticed that this statement holds for all samples except for cement No. X. From these two diagrams it was concluded that either lime or magnesia was the constituent sought. The similarity between the calcium oxide and the magnesium oxide curves is explained by the fact that in all the samples the sum of the per cent. of magnesium oxide and the per cent. of calcium oxide was nearly a constant. These diagrams were found not to agree with the curve representing the loss in per cent. by freezing. However, they suggested the fact that the loss was probably due to entirely different causes in Portland and natural cements. Upon this suggestion other diagrams were made considering the Portland and natural cements separately. In comparing in that manner it was found that the calcium oxide curve did not agree with the per cent. loss curve. The magnesium oxide was then taken up as shown in diagram Fig. 2. Comparing the Portland cements, no resemblance was found between the magnesia curve and the per cent. loss curve. It was noticed, however, that the Portland cements showing a high tensile strength in parallel showed a comparatively low per cent. of loss by freezing, while those Portlands which were not of high tensile strength showed a large per cent. of loss. In the diagram of the natural cements it was seen that the general direction of the per cent. loss curve followed that of the magnesia curve. It was also noticed that the natural cements of comparatively high tensile strength did not show the least per cent. of loss as was the case with the Portlands. Further examination of per cent. loss and the magnesia curve showed that the per cent. of loss seemed to be directly proportional to the amount of magnesia. This being true, the per cent. of loss divided by the per cent. of magnesia should be a constant. In order to investigate this point the following table was computed:

TABLE I.—Showing Chemical Compositions of Ten Different Brands of Cements subjected to Comparative Tests under Normal Conditions and After Freezing.

Name.	Silica.	Ferric oxide.	Aluminum oxide.	Calcium oxide.	Magnesium oxide.	Potassium oxide.	Sodium oxide.	Total alkali	
I. Louisville Starr	23.39	2.16	5.96	41.28	15.39	.81	1.17	1.98	
II. Alsen	21.03	2.72	7.80	62.55	1.46	.85	.94	1.79	
	19.84			62.31	2.29				
III. Dyckerhoff	19.80	3.14	8.94	62.29	2.22	1.13	1.07	2.20	
IV. Louisville Diamond	22.54	2.14	8.24	42.31	5.39	.45	2.37	2.82	
	22.22								
V. Germania	22.21	2.17	7.92	62.08	1.24	.68	1.10	1.78	
VI. Hydr. Utica	19.80	1.85	11.61	29.51	20.38	1.06	4.90	5.96	
						.50	1.51	3.01	
VII. Hoffman Ros.	21.73	4.14	11.18	33.77	21.20	1.53	1.46	2.99	
	24.63			62.80	.87				
VIII. Henry De Fosse	24.60	2.38	6.30	62.73	.86	.46	.78	1.24	
IX. Union Akron	17.14	2.00	7.61	36.83	25.09	.98	2.66	3.64	
						.77	1.35	2.12	SO_3
X. Buckeye	21.20	3.33	6.05	58.07	2.80	.79	1.41	2.20	2.41

sulphur or sulphide .067

TABLE II.—Showing Comparative Strengths of Different Brands of Cements Tested at Different Ages under Normal Conditions and After Freezing.

	Parts by Weight		Strength in lbs. per sq. in. after freezing at ages of,					Strength in lbs. per sq. in., normal conditions, at ages of,				
	Cement.	Water.	7 days.	14 days.	21 days.	28 days.	Average.*	7 days.	14 days.	21 days.	28 days.	Average.*
Louisville Star	14	5.4	41	36	28	59	41	82	106	67	82	84
Alsen	16	3.9	152	231	256	278	230	427	572	498	737	558
Dyckerhoff	16	3.5	224	176	269	264	233	508	586	487	758	580
Louisville Diam	14	4.8	89	37	74	68	67	160	173	178	179	173
Germania	16	4.1	124	154	158	214	163	285	379	429	669	438
Hydr. Utica	11	4.3	23	39	63	54	45	92	146	191	234	166
Hoffman Ros.	16	4.8	10	39	47	49	36	136	154	191	209	185
Henry De Fosse	17	4.0	81	54	108	80	81	406	423	498	722	512
Union Akron	14	3.9	25	16	28	36	26	119	182	151	190	161
Buckeye	15	4.3	0	0	0	0	0	134	225	316	59	184

*(These averages are useful for this comparison only—Ed. Eng. News.)

Name of cement.	Per cent of loss. Per cent of MgO.	Probable error.
Louisville Star	3.28	.44
Louisville Diamond	3.91	.19
Hydraulic Utica	3.58	.14
Hoffman Rosendale	3.78	.12
Union Akron	3.32	.11

In the ratios of the table there is a range of about 0.7 (from 3.28 to 3.91), and the "probable error" of the results is sufficient to account for this variation. Hence the variation of the quan-

*Thesis receiving second honorable mention in Engineering News Thesis Competition for 1895.

tity is probably due to the error of observation, rather than to any error in the theory proposed.

In reviewing the experiments the following conclusions were drawn:

(1) The loss of strength by freezing in natural and Portland cement does not come from the same cause.

(2) The cause of loss of strength in Portland cements is in the main a physical one; the magnesia may have some small effect, but it is insignificant as compared with the physical cause.

(3) The per cent. of loss of strength in natural cements varies directly as the amount of magnesia which the cement contains. In these cements the physical cause does not make itself apparent.

(4) A Portland cement which has the chemical composition of a good cement and which has a comparatively low ultimate strength suffers a greater per cent. of loss by freezing than one which has a high ultimate strength. This tends to show that a large per cent. of loss in a Portland cement is due to careless handling in manufacture.

THE STEAM PLANT OF THE NATIONAL ELECTRICAL EXPOSITION.

The steam boiler plant of the National Electrical Exhibition, which is about to open in New York city, was especially designed, by a committee appointed for the purpose, to be a strictly modern plant, containing only the latest appliances in the market.

The steam is generated by a battery of 500 HP., of the improved Root water tube boilers, manufactured by the Abendroth & Root Mfg. Co., of New York.

The coal is supplied to the boilers by the well-known anthracite automatic stoker, manufactured by the Wilkinson Mfg. Co., of Bridgeport, Pa.

The coal, after being dumped at some distance from the boilers, in the rear, is taken by a coal conveyor, designed and built by the C. W. Hunt Co., of New York, and carried along the side and a little past the front of the boilers, where it is elevated to a point near the ceiling, whence it is delivered through tubes to the hoppers of the Wilkinson stokers. From the stokers it is fed uniformly down the inclined grates, burning on its way, and reaching the foot of the grates as ash, which is dumped into the ash pit below. A Hunt ash conveyor next takes the ash and carries it back to a dumping place some distance in the rear of the boiler, dumping it there automatically. Both coal and ashes are thus handled entirely by machinery, without any shoveling or other hand labor.

The boiler feed-pump is one of H. R. Worthington's make. It is electrically driven by a Crocker-Wheeler Co. pump motor. The pump is of the "steeple pattern," and combined with its motor presents a novel and elegant appearance.

An automatic damper regulator, made by the Locke Damper Regulator Co., of Salem, Mass., completes the equipment, and makes the entire working of the whole plant automatic.

So safe and simple is the operation of this plant, that it has been put in charge of a woman, in order to show to visitors that if steam users will put in the latest steam boiler appliances to secure automatic working, the boiler plant can be operated by a woman as well as by the most expert fireman.

The valves used in the main steam piping are especially adapted to high pressure and ordinary rough handling. They are heavy, straight-way valves with an outside yoke and screw, and are made by the Chapman Valve Mfg. Co., of Indian Orchard, Mass. The pressure carried by the boilers will be 125 lbs. This pressure will be carried along the main steam piping to a point just beyond the first engine, and there it will be reduced by a Foster reducing valve to 90 lbs., at which pressure it will be carried to all of the other engines on exhibition.

The steadiness of the working of this reducing valve will be shown by two Edson recording gages, in the exhibit of the Ashcroft Mfg. Co. nearby, one recording the pressure of steam at the boiler, and the other the pressure on the low-pressure side of the reducing valve.

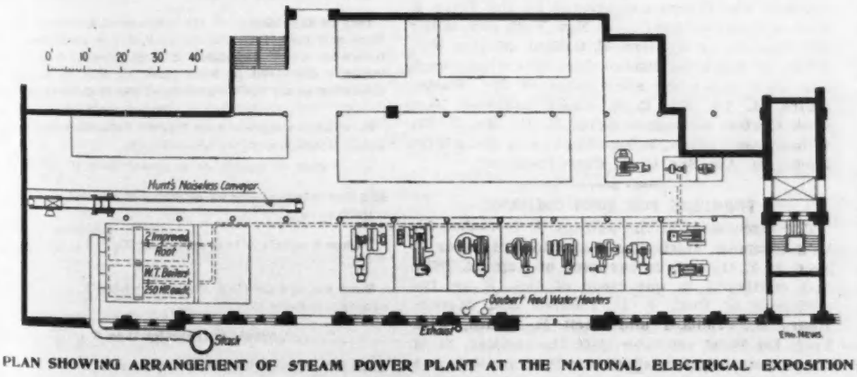
The Foster Engineering Co. also exhibit their new automatic safety stop valve, which is placed in the main steam pipe, near the boiler. This valve will instantly and automatically close in case of a rupture in the steam pipe or the breaking of any of its fittings.

The engines on exhibition will all be direct connected with electric generators with only two exceptions, where belt connections will be used.

The engines are arranged in the following order, beginning with the engine nearest to the boilers: Phoenix engine (the only compound engine); Ball & Wood engine; Straight Line engine; Harrisburg engine; Watertown engine; Payne engine; McEwen engine; Weston engine (belted); New York Safety engine (belted); Case engine; Shepard engine; Woodbury engine.

The exhaust from all of these engines will be passed through a Goubert feed-water heater and then delivered through a Root spiral-riveted exhaust pipe (placed outside of the building) to a point above the roof.

Two concerns share the steam pipe covering work, one putting on Keasby's magnesian sectional covering, while the other applies Gilmour's asbestos covering.



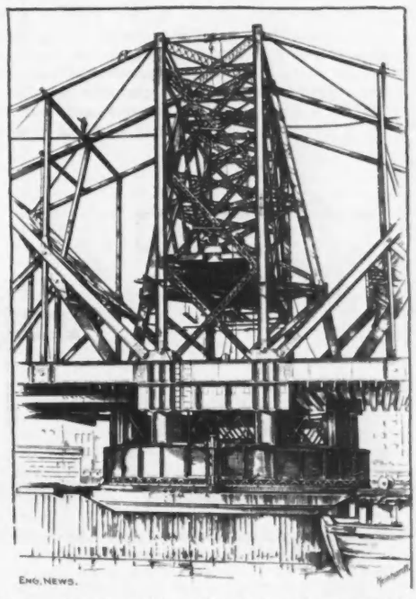
PLAN SHOWING ARRANGEMENT OF STEAM POWER PLANT AT THE NATIONAL ELECTRICAL EXPOSITION; NEW YORK CITY.

Two Root feed-water regulating devices will work in connection with the boilers and the feed pump, starting the pump automatically when the water level in the boiler falls below its proper level, and again stopping the pump when the water in the boiler reaches its normal working level.

FOUR-TRACK SWING BRIDGE OVER HARLEM RIVER, NEW YORK CENTRAL & HUDSON RIVER R. R.

(With inset.)

As the readers of Engineering News know, the New York Central & Hudson River R. R. has been at work for some years making very extensive and costly improvements on its four-track line entering New York city. The general plan of this improvement was described in considerable detail in the issues of this journal for April 13, May 25 and June 15, 1893, but it may be summarized briefly as consisting of the construction of a four-track viaduct from 110th St. to the Harlem River and a high-level four-track swing bridge across the river, with a short viaduct approach and an elevated embankment north of the river. An unusually interesting part of the improvement is the swing bridge, which, although not of very great span, is very heavy. In Engineering News of June 15 and Aug. 31, 1893, the general elevation and plan of this bridge and details of the trusses and the method of supporting them on the turntable were illustrated and described in detail. In this article we illustrate and describe the machinery for operating the bridge, completing our description of the main structural features of this vast work.



Perspective View of Pivot Pier, Harlem River Drawbridge.

Some idea of the work which the operating machinery has to do may be obtained from the statement that the bridge consists of three trusses 389 ft. long c. to c. of end pins, and 26 ft. apart in the clear, carrying four tracks on a ballasted floor of steel troughs, and giving a weight of 5,000,000 lbs. to the total structure. The machinery turns the bridge, unlocks and locks the ends of the trusses, and lifts the ends of the rails.

The power for operating the turning and lifting machinery is generated by two 10 × 7-in. oscillating engines, built by Joseph Edwards & Co., of New York, which firm also built the two 50-HP. vertical boilers and all the gearing in the engine house. This engine is located in an engine house elevated above the tracks and extending transversely across the bridge between the outside trusses at the center. Fig. 1 is a general plan of this engine house, which shows the relative location of the power machinery, the various gears and shafts necessary to convey the power to the turning and lifting mechanism, and the lockers, work bench, boiler feed pump and minor auxiliary conveniences.

The engines are coupled to the main shaft, extending the whole length of the house and transversely across the bridge, by means of differential gears arranged in a ratio of about 19 to 1. This shaft is controlled by means of brake wheels and brake bands operated by independent steam cylinders. Either engine can turn the bridge alone if necessary, the power in such cases being transmitted through extra gears, which reduce the turning speed one-half, thus reducing the stress on the machinery.

At each end of the main shaft is a bevel pinion meshing with a bevel spur wheel at the top of a vertical shaft, which goes down through the side truss to the turntable and has at its bottom a pinion gearing with the face of a rack bolted to the masonry of the pivot pier. Fig. 2 is a part plan and transverse section of the turning drum, which is pivoted on a cast-steel pivot and travels

on two concentric live rings of steel rollers, the axles of which extend only through the circular spacing rings. The construction of the pivot and rollers is shown in detail in Fig. 3. It will be noticed from Fig. 2 that the radials connecting the spacing rings are latticed struts instead of solid rods. There are 16 of these struts. Fig. 2 also shows the location of the vertical shaft in relation to the drum, and Fig. 3 a detail of the pinion and rack. This pinion, the rack and all gear wheels are of cast steel. The turning machinery will revolve the bridge through an angle of 56°, or to the open position, in two minutes.

The operation of the locking gear is a little more difficult to explain. Beginning in the engine house, Fig. 1, it will be seen that spur gears on the main shaft drive a parallel locking shaft. The levers operating the clutches which actuate these spur gears are so arranged that when the gear driving the locking shaft is in action,

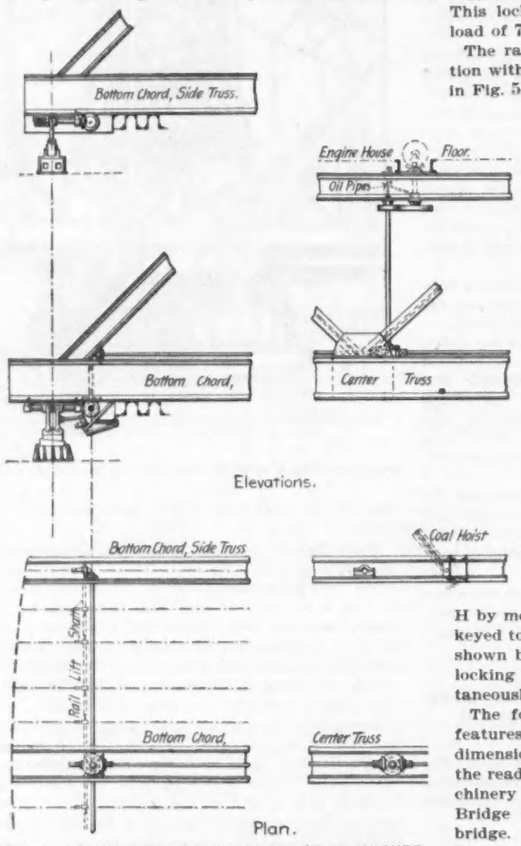


FIG. 4.—DIAGRAM SHOWING MANNER OF TRANSMITTING POWER TO END LOCKS.

that driving the turning mechanism is out of action. By this arrangement the two operations of turning and locking cannot be performed simultaneously, thus causing a breakage in the machinery. At the middle of the locking shaft in the engine house is a bevel spur wheel meshing with a bevel pinion on a short vertical shaft, having at its lower end a horizontal pinion. This horizontal pinion drives a spur at the top of a vertical shaft extending down through the center truss. This vertical shaft drives by means of a bevel gear at its bottom a horizontal shaft extending the whole length of the center truss about 4 ft. above the floor. At the ends of this horizontal shaft the power is carried down through the chord by vertical shafts having bevel gears at their tops. These vertical shafts operate the transverse shafts which actuate the toggles locking the trusses. The diagram, Fig. 4, shows clearly the method of transmitting the power just described.

Details of the locking devices for the center truss are shown in Fig. 5. The bevel spur A at the bottom of the vertical shaft meshes with the bevel spur B in the transverse shaft, and operates the spur C, which actuates the pinion D. The shaft on which pinion D is mounted is threaded right and left, and passes through the right and left crossheads E, E, running in horizontal guides. The right and left horizontal travel of these two crossheads raises the shoe F by means of the toggles G, G. It will be seen that by this arrangement as the ends of the bridge are lifted to their proper position the toggles become more nearly vertical, thus increasing the lifting power as more power is needed. To aid in centering the bridge the shoe F is provided with a V-shaped projection fitting into a groove in the bearing casting on the pier.

The shaft C conveys the power for operating the locks at the side trusses in the manner clearly shown by Fig. 4. In Fig. 6 details of the locks for the side trusses are given, and, as will be seen, they differ but little from the locks for the center truss already described; there is but one toggle, and the shoe is different in construction. This locking mechanism is designed for a live load of 784,000 lbs. and a dead load of 270,000.

The rail-lifting devices are operated in connection with the lock for the center truss. As shown in Fig. 5, the right-hand toggle operates the shaft H by means of the arm and bell crank K. Levers keyed to the shaft H raise the ends of the rails, as shown by Figs. 5 and 7. It will be seen that the locking and rail-lifting devices operate simultaneously.

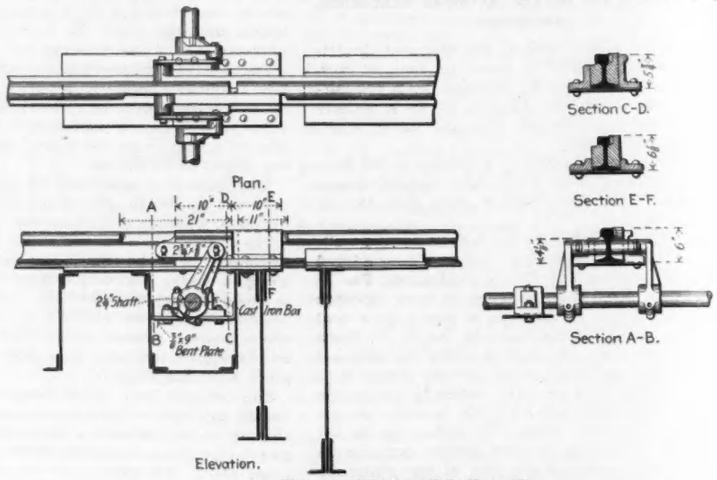


FIG. 7.—DETAILS OF RAIL LOCK.

The foregoing is a description of the general features only of the operating machinery; for dimensions, material and details of construction the reader should refer to the drawings. This machinery was all designed and built by the King Bridge Co., Cleveland, O., contractors for the bridge. The bridge was erected by the Terry & Trench Construction Co., of New York city, under the direction of Mr. Geo. E. Gifford, M. Am. Soc. C. E., of the King Bridge Co. The whole work has been under the supervision of Mr. Walter Katte, M. Am. Soc. C. E., Chief Engineer, New York Central & Hudson River R. R., Mr. F. W. Wilson, Asst. Engr., Bridge Dept., and Mr. Albert Lucius, M. Am. Soc. C. E., Chief Inspector.

FORMULAS FOR LONG COLUMNS.

The discussion on the subject of formulas for long columns, which was begun by the paper of Prof. A. J. Du Bois in our issue of Aug. 22, 1895, and continued in our issue of Oct. 3 by the criticisms of Prof. J. B. Johnson and Messrs. Henry S. Prichard and Cecil B. Smith, with Prof. Du Bois' rejoinder, left the subject in a rather unsatisfactory shape. If Prof. Du Bois and Prof. Johnson disagree so diametrically in their mathematical analysis of a problem, how can the young engineer who possesses no such analytical ability as these two gentlemen attempt to decide between them; and if he reaches a decision, how can he even then feel any assurance that he has not made a mistake?

Instead of continuing the discussion in our correspondence column upon its original lines, therefore, we endeavored to bring about a further discussion between Professors Johnson and Du Bois in the hope that they might reach an agreement, which we could then publish as the conclusion of the discussion.

This purpose, however, we were unable to effect, and it was finally arranged, therefore, that one letter from each party should close the discussion. These letters, moreover, as will be seen below, are not merely defenses by each party of his own position; but in each case the writer has made an analysis of the points in dispute and of the position of himself and his adversary concerning them. This we believe will materially aid those of our readers who may attempt to follow the discussion and decide for themselves what the correct position is.

We have received several other contributions to this discussion, which lack of space forbids us to publish, except in one case, where the writer is very brief and in his last paragraph appears to shed some light on the main point in controversy. We append the letters as follows:

Sir: Prof. A. J. Du Bois has given us on p. 115, Engineering News, Aug. 22, 1895, very simple "Rational Column Formulas," particularly the formulas for symmetrical section. It would be interesting and valuable information if he would give to the readers of Engineering News his idea what valuation should be assigned for the co-efficient of elasticity and the elastic limit, for each of the following materials: Cast iron, wrought iron, mild and hard steel, white pine, yellow pine and white oak; also the factor of safety for bridges and roofs.

I imagine that while the formulas might give satisfactory results for steel and wrought iron, the result for cast iron or cast steel would not be so satisfactory on account of the great difference in the tensile and compressive strength of these metals. Yours respectfully,

New York, Nov. 12, 1895. Frank Pearl.

Sir: In the matter of the discussion between Prof. Du Bois and myself on the subject of his proposed column formulae which appeared in Eng. News, Aug. 22, and which I discussed in your issue of Oct. 3, I offer the following as my understanding of our respective positions:

1.

On what assumption does Euler's formula become applicable? Johnson says for pivoted ends,

$$\text{when L equals or is greater than } \pi\sqrt{\frac{EI}{W}} \qquad (1)$$

and that it is the same for all forms of cross-section.

Du Bois says,

$$\text{when L equals or is greater than } \pi\sqrt{\frac{\left(1+\frac{V}{V'}\right)EI}{W}} \qquad (2)$$

Thus for symmetrical sections, where $V_1 = V$, Du Bois's equation reduces to

$$\text{L equals or is greater than } \pi\sqrt{\frac{2EI}{W}} \qquad (3)$$

while for unsymmetrical sections where $V_1 = \frac{1}{2}V$ it becomes

$$\text{L equals or is greater than } \pi\sqrt{\frac{\frac{3}{2}EI}{W}}$$

and for $V_1 = 2V$ it is

$$\text{L equals or is greater than } \pi\sqrt{\frac{3EI}{W}} \qquad (4)$$

Johnson says Euler's formula applies when that condition of unstable equilibrium is reached such that if the load be diminished the column straightens up, but if it be increased the column increases its deflection to its elastic limit and failure. All this quite independent of the elastic strength of the material, but only dependent on

the resilient or elastic property of rigidity or stiffness. That is, it depends on E and not on S_r.

Du Bois says it applies when $\frac{W}{A} - S_r = 0$, or when there begins to be tension on one side of the column. Johnson claims this fact of "no compression on the convex side," is not pertinent in any sense in determining the question of the application of Euler's formula.

2.

Can V and V_1 be evaluated in Du Bois formula? Johnson says No. Du Bois says V_1 is always the greater of the two, or the column will always bend so as to put V_1 on the concave side.

Johnson says for a symmetrical load, inside its elastic limits, it will START to bend either way, with equal freedom, and after having started to bend in one direction it cannot afterwards change its "inclination" and go the other way, even though it would have found its elastic limit sooner had it gone the other way. (See Vol. IV. of Prof. Tetmajer's Reports of Laboratory Tests, Zurich, where detail results are given of 465 tests of wrought-iron and steel columns of various unsymmetrical structural forms, for a complete experimental proof of this statement.)

Du Bois says it will START in the direction in which its elastic limit is soonest reached for a given deflection.

Johnson says it is equally likely to start in the opposite direction, and having started it cannot turn back. Hence we cannot tell whether to use V or V_1 for the greater distance to the outer fibre.

3.

In the case of a T iron having a 4-in. flange and a 3-in. web, the neutral axis is twice as far from the extreme side of the web as from the extreme side of the flange. According to Du Bois's formula (above (5) p. 116 Eng. News) taking E = 28,000,000 and the elastic limit at 42,000 lbs., and with $\frac{1}{r} = 45$, we have $\frac{W}{A} = 46{,}600$ lbs. per sq. in., for $V = 2V_1$, or $\frac{W}{A} = 32{,}700$ lbs. per sq. in. for $V_1 = 2V$. Hence if the column should START to deflect so as to put the flange on the concave side, the column would carry a load per square inch of 4,600 LBS. PER SQ. IN. MORE THAN ITS ELASTIC LIMIT, which, for soft steel, must be regarded as ultimate strength. On the other hand, if it bends in the other direction, its strength is only 32,700 lbs. per sq. in. Johnson claims both these results are absurd.

4.

Johnson admits that while it appears from the equations that if the ordinary length of column SHOULD bend in the direction of the shorter V, it would carry a greater load at the elastic limit, yet it is an even chance that it will go either way. Furthermore, if it should bend so as to put the nearer outside fiber in compression it certainly would not be able to carry an average load in excess of the ultimate strength, as it does do by Dubois' formula when it bends in this direction, as shown in (3) Here $\frac{W}{A}$ is greater than S_c, which is absurd, and yet Johnson affirms the column is as likely to bend in this direction as in the other. Hence, he argues, the formula cannot represent any true physical law.

5.

Because by his formula the column carries a greater load when bending towards the smaller V, Dubois affirms that hence the column is " stiffer in this direction." Johnson says not so at all. He thinks here is a confusion of ideas as between stiffness and strength. While admitting that it has a higher elastic limit when bending in this direction he affirms its stiffness within both elastic limit loads, or when it begins to bend, is the same in both directions.

6.

Referring to the graphic representations of the three loci of this formula for $V_1 = \frac{1}{2}V$; $V_1 = V$; and $V_1 = 2V$ (see diagram, (Fig. 1), we see:

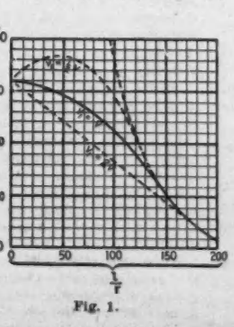


Fig. 1.

(a) That for $V_1 = \frac{1}{2}V$ the strength of the column increases with increasing length up to $\frac{1}{r} = 45$, where it is 11% greater than for a zero length, or than the elastic limit, or breaking down limit of the material. This is evidently absurd.

(b) For $V^1 = V$, we have Johnson's parabolic locus, starting horizontally from the elastic limit point on the vertical axis; that is to say the strength here is constant for increasing lengths, which Johnson thinks is entirely rational and agreeing with the experiments of C. A. Marshall. (Trans. Am. Soc. C. E., Vol. XVII., p. 53.

(c) For $V_1 = 2V$, we have a straight line from the elastic limit point on the vertical axis drawn tangent to the locus of Euler's curve. This, Johnson thinks, is both irrational and in conflict with the results of all experiments. Thos. H. Johnson uses a right-line formula, but he has it cut the axis far above the elastic limit point, and thus, while it agrees with the experiments for the usual lengths, it passes far above them for very short lengths. It, however, makes no pretense of being rational.

7.

In conclusion, Johnson affirms that Dubois has introduced a purely arbitrary and false criterion into his condition of applicability of Euler's formula, which false equation of condition leads to a formula for shorter lengths which cannot be evaluated in practice for unsymmetrical sections and which leads to absurd results with such sections, whichever way the column should happen to bend. With one way of taking V and V_1 the results are absurdly high, and with the other way they are absurdly low, though which way they should be taken could not be determined until it is known which way the column will decide to bend. Very truly yours,

J. B. Johnson.

Washington University, St. Louis, Nov. 19, 1895.

(To the above letters of Mr. Pearl and Prof. Johnson, Prof. Dubois replies as follows.—Ed.)

Sir: Before replying in detail to Prof. Johnson, allow me to give the following brief and simple presentation, free from all algebraic work, which covers I think all the points raised and will enable any one interested to judge for himself as to the points at issue.

As the length of a column increases it bends more and the effect of flexure as compared with that of direct compression increases. Of course direct compression can never disappear. But is there a length beyond which its effect can be practicaly neglected? The reply is, that Euler's formula neglects all direct compression, and yet in the case of long columns experiment proves that it gives the crippling load very satisfactorily. The next question that arises is, can we find that limiting length L, beyond which Euler's formula can be thus depended upon? If so, we can use Euler's formula for all lengths greater than L. For less lengths, any curve tangent to Euler's curve at the length L, can be used, if it gives the crippling unit stress equal to S_c (the elastic limit unit stress) for zero length. Any curve will do, because whatever the true curve may be for an ideal column, since no column is ideal, actual results will be scattered above and below this true curve. We thus obtain one continuous curve for all lengths.

Now to find L. In the accompanying Fig. 2 let W be the gradually applied load which just crippies the column, so that the unit stress on the inside is S_c, (the elastic limit unit stress). This load W is gradually applied and is given by ordinary experiments on strength of columns. Let A be the area of cross-section denoted by a b, the center of gravity being at n. Then, if there were no deflection of the column, the unit stress of direct compression would be $\frac{W}{A}$ uniformly distributed (represented by mn.) But if the column bends, the stress is no longer uniformly distributed, but the unit stress $\frac{W}{A}$ is diminished on the convex side by the unit stress S_f due to flexure, so that the effective unit stress on that side is now represented by a d and is still compression. On the concave side we have evidently $\frac{W}{A}$ increased by $\frac{V_1}{V} S_f$, represented by g c (where V_1 and V are the distances from the axis m n to the concave and convex sides respectively). We thus have a unit stress represented by a d of direct compression, which is still uniformly distributed. This I call the "uniform direct compression." This is not, of course, all the direct compression, but the rest of the direct compression is not uniformly distributed. The inclination of the column or deflection is towards the right as indicated in the figure. It corresponds to the line c d.

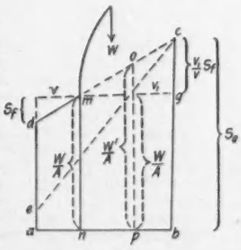


Fig. 2.

If now the length is increased and we decrease W so that the unit stress on the concave side is always S_c, we shall arrive finally at a length L for which the uniform direct compression a d will be zero. Up to this length we have compression on the convex side. Beyond it we shall have tension.

Now Euler's formula assumes true flexure, that is, tension on one side and compression on the other. But up to the length L there can be no tension. Beyond it Euler's assumption is for the first time allowable. This then is the limiting length for Euler's formula.

One other point I must notice. The strength of a beam is measured by the work required to break it. In the case of true flexure only, the least strength is for the plane of bending through the least radius of gyration, and interchanging V and V_1 simply interchanges the stress in the outer fibres. The deflection is then (theoretically, if S_c is the same for tension and compression) the same in either case, for the same load. Hence the work is the same and the strength is the same either way of bending.

But in our case (see Fig.) if V and V_1 are interchanged, we see at once that for greater V_1 and W gradually applied, we have at the breaking point a deflection corresponding to c d. For the same load W gradually applied and least V_1, we have at breaking point, a greater deflection, corresponding to c e, and the work (represented by the area a e c b) is less than before. That is, the column is not so strong when bending in direction of least fiber distance. It also bends more for the same load or is not so stiff. It therefore bends easiest or is "most likely" to bend in the direction of least fiber distance. We also see that if we wish to break the column AT THE SAME DEFLECTION (corresponding to c d) in both cases, we shall have to apply a load W^1 represented by o p greater than W (please note the prime). This load W^1 must then be applied suddenly. My formula gives both W and W^1. THE GRADUALLY APPLIED LOAD W IS THEN ALWAYS FOUND BY TAKING V_1 IN THE FORMULA AS THE GREATEST FIBER DISTANCE. This gives the strength as found by ordinary experiment. The column bends easiest in the direction of its least fiber distance, BUT W IS THE SAME IN BOTH CASES. The other value W^1 is not given by ordinary experiments. It is the suddenly applied load which will break the column before the deflection corresponding to c e is attained at the same deflection c d as W.

Any reader can now judge for himself. Taking up Prof. Johnson's statements in numerical order:

1.

On what assumption does Euler's formula become applicable? I answer, upon the assumption of true flexure. Upon this assumption I have found the length L beyond which we can accept Euler's formula. Prof. Johnson has also found a value for L. My value includes his as a special case, because he ignores V and V_1, and I do not. He simply asserts that V and V_1 do not make any difference. Well, assertion is not proof. I refer to my opening remarks and Fig. and reply that I see no flaw in my reasoning, and do not see how V and V_1 can be disregarded.

The greatest fiber distance V_1 occurs in all formulas for beams, and it enters here in the same way and for the same reasons. When Prof. Johnson can get rid of V_1 in these formulas it will be time to make his assertion as to the present one.

Prof. Johnson takes $V_1 = \frac{1}{2}V$. As we have seen this does not give W but W^1.

Prof. Johnson says that "Euler's formula applies when that condition of unstable equilibrium is reached such that if the load is diminished the column straightens up, but if it be increased the column increases its deflection to its elastic limit and failure."

I say, Amen! That is just what I think. When the stress in the outer fiber at limiting length L is zero, that is just the state of things. Up to that length the load W is always directly over the equal and opposite reaction of the base and we have two equal and opposite forces in the same straight line. At that length, if the column is pushed slightly, the load W will pass the equal and opposite reaction, we shall have at once a couple acting to increase the deflection, and the column instead of returning will take a new position of equilibrium. At the length L the column then is at the verge of unstable equilibrium, because at this length the stress in the outer fibre is zero. Yet Prof. Johnson claims "this fact of no compression on the convex side is not pertinent." Why, it is absolutely necessary for his own position!

2.

Can V and V_1 be evaluted? I HAVE ALREADY SHOWN THAT V_1 IS ALWAYS TO BE TAKEN AS THE GREATEST FIBER DISTANCE TO FIND W. It is thus known in all cases. I do not, however, say, that "the column will always bend so as to put the value of V_1 on the concave side." On the contrary, I say it bends easiest in direction of at least fiber distance. This is in accord with familiar experience. In the case of the English "long-bow" the cross-section is like that of the letter D. It is stiffest in the direction of greatest V. More work is done in this direction for the same deflection.

I do not say a column will "start" in any known direction. No man knows that. Inequalities, imperfections, external influences, all tend to determine the "start." On the theory of probabilities it is as likely to "start" in one direction as another. But all Prof. Johnson's remarks on this head have no pertinence. It is recognised by all, for instance, that the column

bends easiest in the plane of the least radius of gyration. Prof. Johnson might just as well attack this on his "start" theory. I simply point out that THE DIRECTION IN THIS PLANE is that of the least fiber distance. In what direction it may "start" is not the question. What we are after is the least load W which will cause failure. The direction for that alone concerns us. If the column "starts" in any other direction so much the better, since we are provided for the worst.

Once started in any direction, the column must continue, and in that case may carry a greater load than if it had started in the direction of least fiber distance. But since the strength is least in this latter direction and there is always the possibility of starting in this direction, we must of course design the column accordingly. Evidently the imposing citation of Prof. Tetmayer's experiments has no value whatever as regards the point at issue.

3.

In the case of the T iron, Prof. Johnson finds the unit load obtained by taking V_1 equal to least fiber distance, greater than S_c. This point I will speak of under 6. I will only say here that I have clearly shown that the greatest fiber distance is always to be taken for v_1, no matter which way the column bends. It is this which gives the least load or the value of W which we wish. The column, however, bends easiest or most in the direction of the least fiber distance, and fails for the same gradually applied load W in both cases, as experiments prove. The fact that my formula gives W^1 (see Fig.) too large, is of no importance and the reason will be mentioned later.

4.

The preceding remarks apply here also. Prof. Johnson here "admits" too much. The average load he finds to be greater than S_c is W^1 not W.

5.

"Because by his formula the column carries a greater load when bending towards the smaller V, Du Bois affirms that hence the column is stiffer in this direction." Here, indeed, is a "confusion of ideas," but not mine. The significance of the greater load W_1 (see Fig.) I have already pointed out. But I do not say that the column is stiffer when bending towards the smaller V. On the contrary, it is stiffer in just the opposite direction. I do not say it caries a greater load, BUT THE SAME LOAD IF GRADUALLY APPLIED. I do not think that the elastic limit stress is changed by direction of bending. That seems to me preposterous. Why Prof. Johnson should volunteer such an extraordinary admission the reader must guess for himself. I give it up.

6.

Now, referring to the graphic representations given by Prof. Johnson, I have shown that $V_1 = \frac{1}{2}V$ gives W^1, not W (see my Fig.) Much trouble seems to be caused to Professor Johnson because he finds $\frac{W^1}{A}$ greater than S_c. The explanation is obvious. The form of equation I have chosen does not give a horizontal tangent at zero length, except for $V = V_1$. For very short columns then we may get $\frac{W^1}{A}$ somewhat in excess of S_c. But we do not wish W^1. I could easily have assumed a form of equation which would have given a horizontal tangent always. In that case Prof. Johnson's criticisms would have had no existence. But although the same practical results would have been obtained, the resulting expressions would not have reduced to the straight line and parabola formulas. I have therefore preferred the form of equation I have chosen, although it gives the value for $\frac{W^1}{A}$ (which we do not care about), in some cases of no importance, a little in excess of S_c, or, what is the same thing, assumes S_c for such cases of very short columns somewhat greater than for longer—a not unreasonable assumption. With this explanation, the reader can draw his own conclusion as to the value of Prof. Johnson's remarks

7.

In conclusion, I would say that I put forward my formula for intelligent criticism and discussion, not expecting it would give rise to such a "campaign of education."

As to the remarks by Mr. Pearl, I can only say briefly that by my formula, within the length L, we have to do only with compressive strength, and beyond L, since we use Euler's formula, S_c does not enter. We have then in the formula the elastic limit S_c for compression only. I should not like to make myself responsible here for a set of values for E and S_c for the materials named. They could be only average, and in practice should be experimentally determined for the case in hand. Mr. Pearl's last paragraph applies equally to the derivation of all the ordinary beam formulas.

A. J. Du Bois.

New Haven, Conn., Nov. 25, 1895.

CAPACITY TEST OF A WATER TUBE BOILER.

A test was made on April 14, of a Combine Safety water tube boiler, manufactured by L. M. Moyes, of Philadelphia, Pa., and recently installed in the station of the Marietta Electric Light, Heat & Power Co., at Marietta, O. The test was conducted by Mr. Jay M. Whitham, M. Am. Soc. M. E., of Philadelphia, Pa.; and Mr. W. B. Le Van, M. Am. Soc. M. E., represented the Electric Light Co The test was made solely to determine the capacity of the boiler. It was rated at 125 HP. (1 HP. = 30 lbs. water evaporated per hour from feed at 100° F. into steam at 70 lbs. gage pressure). The boiler had three drums, 42 × 81 ins., and 60 tubes, each 4 ins. × 16 ft. The heating surface was 1,100 sq. ft., and the grate surface, 21.875 sq. ft. Draft was furnished by a stack 40 ins. diameter, and 122 ft. high.

The test was continued for 8 h. 39 min., with a flying start and stop. The coal was from the Sussman Shaft, Clearfield County, Pa., and had 2% moisture, 11.13% ash, and consisted of about 30% large lumps, 50% small lumps and 20% slack. The results of the test, together with the conclusions reached, are given as follows in Mr. Whitham's report:

Moisture in steam by the Barrus Calorimeter	0.13 of 1%
Water evaporated from and at 212° F. per lb. of dry coal, lbs.	9.346
Water evaporated from and at 212° F. per lb of combustible, lbs.	10.52
Boiler HP. actually developed, by basis of 30 lbs. per hour from 100° F. at 70 lbs. pressure	161.4
Rated HP. of boiler	125.
HP. developed above rating	29.1%
Dry coal burned per hour per boiler HP. developed, lbs.	3.69
Wet coal burned per hour per boiler HP. developed, lbs.	3.76

The boiler HP. developed from hour to hour was about as follows:

Hour	1	2	3	4	5	6	7	8	9	Ave.
Rate, HP.	138	150	161	160	171	150	179	168	172	161.4

1. The boiler steams freely and with ease.

2. The steam is remarkably free from moisture, being practically dry.

3. The water level is very steady, not vibrating, under the conditions of working this test, over 1 in.

4. The walls of the boiler setting are covered with a plaster of non-conducting material, and were colder than any walls ever noted by the writer. This retention of heat in the setting is conducive to economy.

5. The distribution of the draft in the various passes of the gases was as follows:

Draft at stack base	0.514 in.
" " second pass	0.445 "
" " top of first pass	0.394 "
" " furnace	0.242 "

This shows a skillful proportioning of the flue areas.

6. The fuel burned having over 11% ash, was not as good as an avearge quality of Clearfield coal. I have made scores of trials of this coal, covering periods ranging from 8 hours to 6 months and find that the Clearfield coal usually found in this market has from 4 to 8% ash, and seldom as high as 10%.

7. The boiler developed with ease 29% excess capacity above its rating, and with good economy.

8. Mr. Levan and I are both of the opinion that this boiler, run at its rating, will show about 10% better economic results. This means that, whereas 3.69 lbs. of dry coal an hour was used per boiler HP. at 29% excess capacity, only about 3.35 lbs. would be required at its rating.

9. The boiler is well suited to supply steam for a steady pull, and also to respond to sudden fluctuations in the demand.

DISCHARGE OF THE 36-IN. RIVETED STEEL CONDUIT AT ROCHESTER, N. Y.

An interesting comparison of the original computations and the actual gagings of the new 38-in. riveted steel conduit connected with the water supply of Rochester, N. Y., is given by Mr. Emil Kuichling, M. Am. Soc. C. E., Chief Engineer of the Rochester water-works, in the last annual report of the Executive Board of that city. As the report can doubtless be obtained by any of our readers by addressing Mr. Kuichling, and is too lengthy for reprinting in full, only a brief summary of it will be presented here.

Mr. Kuichling desired to provide a conduit which would carry 16,000,000 gallons per day. He first determined the proper size of a cast-iron pipe for this service, allowing a decrease of 20% in the carrying capacity after a number of years of service. In other words, he made his estimates for a clean cast-iron conduit with a capacity of 20,000,000 gallons a day, which he found would be 34½ ins. in diameter. He thereupon assumed a 36-in. cast-iron pipe, and after careful calculations allowed about 5% for the extra friction of a lap-jointed and riveted steel pipe, which gave 38 ins. as the proper diameter of his conduit.

The first section of the conduit extends from near Hemlock Lake to the Rush reservoir, 17.356 miles, or 91,641 ft. The mean elevation of the water at the head of the conduit was 371.89 ft. for the first gaging and 372.120 for the second. The "computed mean topographical elevation of water surface in piezometer at end of conduit" was 280.74 ft. for the first and 279.102 ft. for the second gaging, giving losses of head of 91.5 and 93.018 ft., respectively. The corresponding mean velocities were 3.2733 and 3.2308 ft. per sec., and the hydraulic grade,

$$s = \frac{h}{e} = \frac{\text{loss of head}}{\text{length}},$$

was 0.00099464 and 0.0010150. The flow for the first gaging was at the rate of 16,661,800 and 16,445,800 gallons per day, but the delivery at the reservoir was through a temporary 16-in. pipe. The conduit had been in service 1.88 years at the first and 2.1 years at the second gaging.

The gagings were made by observing the rise of water in the reservoir. The hydraulic pressure in the conduit near its connection with the inlet pipe was noted by means of a mercury column and the elevation of water at the head of the conduit was also recorded. The accuracy of these gagings was also checked by weir gagings at Hemlock Lake.

About 72% of the steel pipe was coated with asphalt and the balance with Prof. A. H. Sabin's japan varnish made by Edw. Smith & Co., of New York city. This section of the pipe line has eleven 36-in. stop valves and five 36-in. cast-iron T-branches for future connections, the castings being joined to the steel pipe by tapering courses. There is also a short length of 36-in. cast-iron pipe at the reservoir.

Gagings were made of a second section of 38-in. steel conduit, extending from Rush to Mount Hope reservoirs. This has a total length of 8.75 miles, including 1,152 ft. of 36-in. cast-iron pipe, specials and valves. It also includes an abrupt turn of 90° through a square-shouldered T-branch for temporary use. The cast-iron pipe had the usual coating and was rather rough. All the steel pipe in this section was coated with Sabin's japan varnish. The total length of the steel conduit alone was 45,400 ft., and the hydraulic grade was 0.001606 as an average of three piezometric observations. For the 1,146 ft. of 36-in. cast-iron pipe the average hydraulic grade for two gagings was 0.0014455. The discharge through the 8.75 miles of steel and iron pipe averaged 19,831,000 gallons for three gagings.

Mr. Kuichling estimates that with proper outlets at the two reservoirs the flow through the 17.356 miles of 38-in. riveted steel conduit to the Rush reservoir would be 19,200,000 gallons and through the 8.75 miles to the Mount Hope reservoir, 21,200,000 gallons. The difference is due to the fact that high water at Rush is 34 ft. above the hydraulic grade line drawn from the head of the pipe to high water at Mount Hope reservoir.

HIGH EXPLOSIVES FIRED FROM SHIP'S GUNS are to be thoroughly tested under the $50,000 appropriation in the Navy bill, provided the Senate amendment is agreed to. This subject, says the report of the Navy Committee of the Senate, has engaged the attention of the Ordnance Bureau for several years. Capt. Sampson, in the last annual report of that bureau, says that the only difficulty in using high explosives as the bursting charge of shells is that of getting a suitable detonator; methods of firing such explosives safely now await trial and hence the appropriation recommended. Foreign countries are experimenting with melinite, lyddite, ecrasite and bellite; but so far as we can learn, the charge of these materials is relatively small, or the velocity of the projectile is low. What is really wanted is a high explosive that will not explode by simple concussion, but that will operate only with a special detonator and can be used in large quantity and with a high velocity. Commodore Folger believes that there will soon be a decided revolution in the armament of warships; the heavy armor-piercing guns and projectiles being retained, but being supplemented by shorter guns of large bore to be used in throwing high explosives against the unarmored parts of ships.